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THE
CHEMICAL WORLD

A MONTHLY JOURNAL
OF
CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY
W. P. DREAPER, F.I.C.

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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OUR PROGRAMME.

OUR aim is a definite one. It is to fill a space in the scientific literature of this country which is not at present fully occupied, and present to those interested in the many branches of Chemistry an account of progress in both theory and practice, discussing such other matters as may be expected to influence the future progress of this science.

The relationship which exists between these different branches on the one hand, and between Chemistry and the other experimental sciences, is a matter of increasing importance. Certain indications of the breaking down of the divisions which have divided the science into so many water-tight compartments and sectionalised Chemistry in the past, may be welcomed by all.

It will be our endeavour to deal with the subject in such a way that this aspect and the relationship between theory and practice will be in evidence.

In educational matters it is our intention to follow and record from time to time the rapid development of the Modern University in its widest sense. This movement is possibly the most important one that we shall have to register, apart from that of actual discovery. The increasing influence of the Institute of Chemistry and the Chemical Societies is also an important and controlling factor in the consolidation of the many interests involved: this and the improvement in the working conditions and increasing prestige of the chemical investigator will also be carefully followed.

In legal matters we shall present from time to time an account of such causes and actions as entail the consideration of chemical problems, which may direct or otherwise influence industrial conditions.

In legislative affairs we shall endeavour to take part in the further development of the influence of scientific thought on the general health conditions and progress of our national life.

So far as space is available the Commercial Notes and Record of Patents will deal with matters of special interest in their respective directions.

Concerning the details of our programme we hope generally to record proceedings of the different Chemical Societies, their annual meetings, etc., and, as in this number, occasionally reprint or abstract such communications as are of special interest, but not generally accessible to the chemist or manufacturer.

In this number will be found the first of a series of illustrated articles on the Chemical Departments of the modern Universities, and Technical Colleges. Each of these will be written by a leading member of the College Staff. In this way it is hoped to extend the knowledge of the ever-increasing facilities which exist in this country for general and specialised instruction.

Serial articles on Colloidal Chemistry and Chemical Research are also commenced. When reprinted these will form the first text-books of the "CHEMICAL WORLD Series." The former subject deals with a matter of general interest to many manufacturers, and to practically all chemists. The arrangement of the subject matter follows that of the recent lectures given by Mr. Hatschek at the Sir John Cass Technical Institute. The Notes on Chemical Research will follow on elementary lines the development in this important branch of chemical practice.

The section dealing with Chemical Engineering will be gradually extended, and mark the general progress in this important branch of applied chemistry.

We have spoken of Education and Legislation. It is our intention to give from time to time the opinion of leading scientists on these important subjects. We aim at the ultimate organisation of a Science Party, which, being directly represented in both Houses of Parliament, will watch and influence legislation on scientific lines.

We would like to thank those contributors who, as leaders in their respective spheres, have so readily come forward with contributions to this New Journal. We could hardly hope to succeed in presenting to our readers an account of general progress without their aid.

The American Mind.

An interesting point was raised at a recent meeting of the London Section of the Society of Chemical Industry. Dr. E. C. Acheson, of Nigeria, was demonstrating his important process of "Deflocculation," apparently reproducing under modern conditions similar results to those obtained over long ages by the Chinese in the production of Indian Ink, etc. He claimed that while his investigations were in progress all reference to theory was purposely avoided. It was only after the experiments were completed that a text-book on Colloids was opened. This essentially practical method of working is naturally not possible in all cases, nor even desirable; but it is evident, as pointed out in discussion, that the American mind, in its essentials, may work in a different groove to the European one.

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The case of Edison and the results he obtained when working on purely empirical lines are known to all. Also his apparent dislike for theoretical speculation as an aid to investigation. Dr. Acheson spoke of the fool venturing to experiment on lines which would have been considered impossible by the man who was well up in theory. Even in investigations which involve theory the same freedom of thought is often evident. Prof. T. W. Richards exhibited this in the last Faraday Lecture on the Fundamental Properties of the Elements. After all it is evidently a question of approaching investigation from different directions. Each method gives results, and it is important that this should be realised. Time alone can determine their relative value. One investigator works along systematic and carefully-thought-out lines; the other is frankly out after treasure-trove, and with past experience to guide him sometimes makes startling discoveries.

Educational Methods:

This point has a significance which may not appear on the surface. It touches the deeper question of educational training. Sooner or later this will be realised, but in the meantime it is difficult to formulate definite conclusions from data obtained under present conditions. The problem can only be dealt with on a scale of averages. It may then be possible for the followers of one system to compare notes directly with those of another, to their mutual advantage.

* * * * *

Science, as Prof. O. N. Witt has insisted, "rests on an empirical basis"—we cannot draw conclusions unless we have well established observations to start with. "Empiricism investigates without foregone conclusions, while theoretical science verifies logical deductions." Thus certain differences in the respective methods of working disclose themselves. It is clear that empiricism has often represented the first advance in research, and theory founded on this has in its turn suggested a basis for further investigation. In some cases it is the absence of *foregone conclusions* which gives a certain type of worker in the experimental sciences an advantage. He wanders naturally along untrodden paths. To that extent he may be regarded as a true explorer.

* * * * *

The same unconventional conditions seem to rule with the American student, as the following recently published particulars will indicate:—

> "More than £15,000 was earned last year by students at Columbia University, who are compelled to work to support themselves during their four-year university course. The largest amount earned in the twelve months by one student was £548, who put in his spare time as Press agent. A second-year man sold stocks on commission and secured a profit of £197. A senior in the law school peddled straw hats during the summer holidays, earning £119. A student in philosophy waited at table for his meals and £69, and, in addition, he received £32 for acting as a subject in psychological tests. A senior in the teachers' college laid bricks during the long vacation, which netted him £72."

* * * * *

Elementary Mathematics.

The importance of a training in Mathematics to the chemist is beyond dispute, and is more than ever essential.

At the meeting of the Association of Teachers of Mathematics held recently, Dr. Whitehead insisted on the treatment of elementary mathematics as a set of fundamental ideas, the importance of which the student could immediately appreciate. Each teacher must therefore make up his mind which ideas are fundamental. The *Times* remarks "that this is a laudable object, thus to seek to economise the time and way of all concerned, but it requires for its fulfilment an amount of discretion and restraint rarely to be seen in company with performed mathematical knowledge." It is also pointed out that the progress of engineering to chemical science is too continuous to permit of rapid reform based upon such principles, but that "experience shows that within the ever-widening area there is a more or less definite patch of common ground which all must traverse if they desire to become skilful in the use of mathematical weapons."

* * * * *

It is evident that the question of training in mathematics is receiving increased attention. An article on "Tradition in Education" in *Science Progress* (Oct., 1911), in summing up the present state of affairs discusses the relative value of mathematics on inquisitive lines in the general curriculum in public schools. This article, and that on "Mathematics in English Schools," in the same number of that Journal, is of special interest at the present juncture, as it summarises present opinion on this important subject.

THE DETECTION OF MYDRIATIC ALKALOIDS IN TOXICOLOGICAL PRACTICE.

By FRANCIS H. CARR, F.I.C.

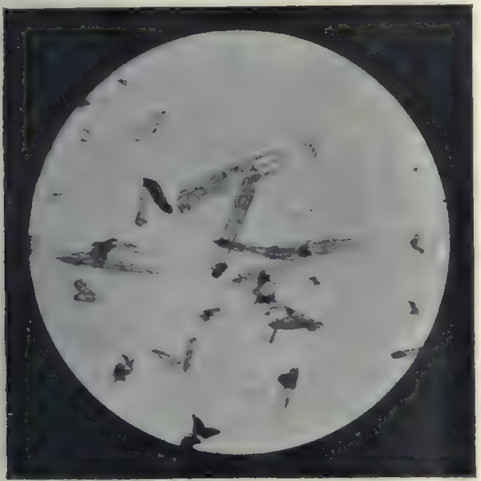
THE highly toxic character of the naturally occurring tropeines and scopoleines—otherwise known as the vegetable mydriatic alkaloids—and the wide distribution of the plants producing them, have led to their frequent use for the purposes of criminal poisoning. It is therefore of great importance that our knowledge of the method of detecting these mydriatic alkaloids should be precise and as extensive as possible.

The chief vegetable mydriatic alkaloids are hyoscyamine, atropine, hyoscine and *i*-scopolamine. There are also certain other bases derivable from them.

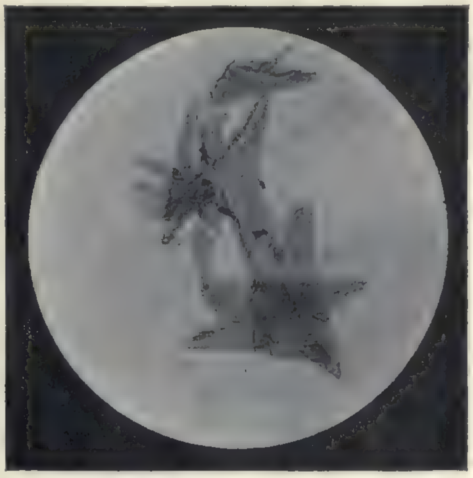
The plants in which they naturally occur belong almost exclusively to the order Solanaceæ: namely, Atropa belladonna and various species of Datura, Hyoscyamus and Scopolia. The alkaloids are consequently sometimes known as the Solanaceous alkaloids. These plants are very generally distributed, and at least one poisonous species is indigenous to nearly all parts of the habitable globe.

The tropeines and scopoleines are for the most part well crystallised bases, forming well crystallised salts. They undergo gradual decomposition at high temperatures. Dilute alkalis readily act upon them, gradually converting those which are optically active into their racemic modifications, and also (though less rapidly) hydrolysing them and splitting off tropic acid. On account of this instability the expert toxicologist carries out the extraction of the alkaloids very rapidly and with the utmost care.

If the dried alkaloidal extract consists of a minute quantity of a mydriatic base it will not readily crystallise, for even pure hyoscyamine in minute amounts obtained by the evaporation of its solution in chloroform or ether is extremely difficult to crystallise. It follows that no evidence is afforded by the melting point or crystalline form of the base, unless a comparatively large amount—0·1 gram or more—is present.



HYOCYAMINE SULPHATE, 1 : 1000.



ATROPINE SULPHATE, 1 : 1000.

The detection of these alkaloids is dependent upon certain tests, the objects of which are severally as follows:—

(1) To show that the base is a mydriatic alkaloid.

(2) To prove that the alkaloid belongs to the group of vegetable mydriatic alkaloids.

(3) To identify the alkaloid by the properties of one or more of its salts or derivatives.

As regards the first and second stages there is no practical difficulty in the procedure.

(1) The proof that the alkaloid is mydriatic is made by administering one or two drops of a 1 : 10,000 solution to the eye of a dog or cat and observing the dilation of the pupil.

(2) Proof that the alkaloid belongs to the group of vegetable mydriatic alkaloids is afforded by the strong alkaline reaction which the base gives with phenol-phthalein, and by the Vitali test. The latter is a colour reaction obtained on treating the substance with a few drops of nitric acid, evaporating on a water bath, and adding alcoholic potassium hydrate, when a magnificent reddish-violet colour is produced. This test, unlike most of its kind, is of real value; and no alkaloid, except those of the group under consideration, has been found to respond to it. The characteristic colour is produced by all the known naturally occurring tropeines and scopoleines, but not by the hydrolytic products, tropine and tropic acid; nor is it given by the synthetic tropeine—homatropine (mandelyltropine).

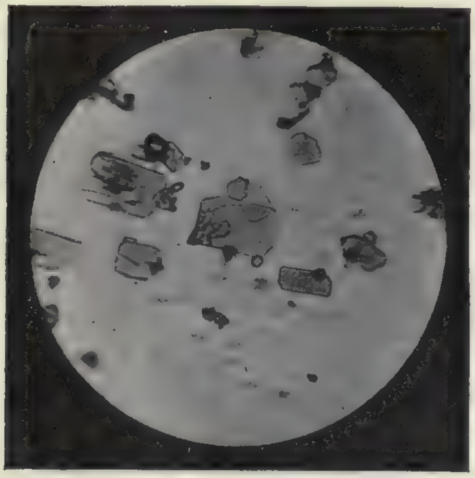
(3) When, however, with a minute amount of material in our hands we are required to determine which of the mydriatic alkaloids is present, we are confronted with a problem of far greater difficulty, requiring much skill and experience in the handling of these alkaloids.

The difficulty is enhanced when either hyoscine or *i*-scopolamine is the alkaloid in question. This problem recently arose—apparently for the first time in English juridical proceedings—followed by a conviction for murder by the administration of hyoscine. The amount of substance available in this case—2/5-grain—being very small, the task of the Home Office analyst was not an easy one. The evidence established the presence of a vegetable mydriatic alkaloid, and identified it as hyoscine—firstly, because it did not crystallise, and secondly, because it gave an amorphous precipitate on the addition of a solution of bromine in hydrobromic acid. The greater reliance was placed upon the result afforded by the latter test.

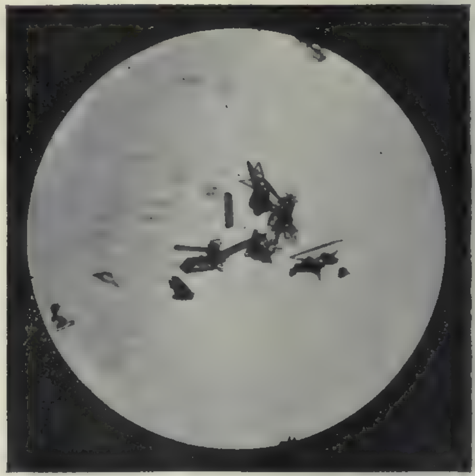
Neither of these tests can be regarded as satisfactorily proving the identity of the alkaloid with hyoscine. The former is unsatisfactory because atropine and hyoscyamine, at all times difficult to crystallise in minute amounts, are especially so when contaminated with such impurities as necessarily accompany an alkaloid that has been separated from animal matter.

The bromine test is also unsatisfactory because, contrary to the statements made at the trial, hyoscine equally with hyoscyamine and atropine gives crystals with the reagent. Wormley, to whom this test is due, states that solutions of hyoscine 1 : 100 give crystals, but that at greater dilutions only reddish-yellow globules result. It must be pointed out, however, that at greater dilutions (even 1 : 2,000) hyoscine and also *i*-scopolamine in fact give crystals. The freshly formed precipitate is in every case amorphous, but rapidly becomes crystalline as viewed under the microscope. The precipitate obtained with hyoscine or *i*-scopolamine takes a few seconds longer to crystallise than that obtained by hyoscyamine; but the test is clearly valueless for distinguishing between hyoscine or *i*-scopolamine and hyoscyamine or atropine.

The following micro-photographs illustrate the crystals which were obtained by adding Wormley's reagent to 1 : 1,000 solutions of salts of the respective alkaloids.



i-SCOPOLAMINE HYDROBROMIDE, 1 : 1,000.



l-HYOSCINE HYDROBROMIDE, 1 : 1,000.

CRYSTALS PRODUCED BY THE ADDITION OF A SOLUTION OF BROMINE IN HYDROBROMINE ACID.

As a preferable alternative to the Wormley test one may prepare, if the available material permits, a sparingly soluble salt, and observe the crystalline form and melting-point, this procedure having the great advantage that the alkaloid is recoverable with only small loss.

The salts best suited to this purpose are the aurichloride and picrate. By the use of the former 1/10-grain of the pure mydriatic base may be identified, and for the latter as little as 1/50-grain will serve. It is possible that in dealing with an alkaloid recovered from the stomach and organs of the body larger amounts than this would be required; but the method is one which affords evidence so much clearer and more exclusive than that furnished by any other test, that in every case an attempt should be made to apply it before using up the material in other ways.

The aurichlorides are prepared by adding a few drops of gold chloride solution to the alkaloid dissolved in a few drops of dilute hydrochloride acid; then, after warming to redissolve and cooling to crystallise, the minute amount of substance is filtered off on a very small filter-paper. The melting-points and crystalline forms of the gold salts are as follows:—

Hyoscyamine aurichloride	165°	Brilliant golden-yellow scales.
Atropine „	137°-139°	Dull pulverulent crystals.
Hyoscine „	198°-200°	Yellow leaflets.
i-Scopolamine „	208°	Yellow leaflets.

The picrates are prepared by adding a few drops of a cold saturated solution of picric acid to a solution of the base or its salt in water. After warming and cooling, crystals are produced, which may be filtered off and washed. The melting points and crystalline form of the picrates are as follows:—

Hyoscyamine picrate	165°-166°	Rectangular plates.
Atropine „	175°-176°	Rectangular plates.
Hyoscine „	180°-181°	Slender matted needles.
i-Scopolamine „	193°	Slender matted needles.

The crystalline forms of the picrates of the two first-mentioned alkaloids differ in a very characteristic manner from those of the two last-mentioned; and this evidence, when taken in conjunction with the melting points of both the aurichloride and the picrate, will establish beyond all doubt the identity of the mydriatic alkaloid under investigation.

In toxicological work it is likely that during the process of extraction hyoscyamine and hyoscine will be converted into their racemic modifications atropine and *i*-scopolamine. The identification by means of the melting points of the salts referred to above is even more distinctive in the case of the racemic salts.

THE CHEMICAL CHARACTERISATION OF SOILS.

By E. J. RUSSELL, D.Sc. (Lond.),

Goldsmiths' Company's Soil Chemist, Rothamsted Experimental Station.

WHEN a chemist is called upon to analyse a sample of soil he is usually expected to give some information about the crops to which it is best suited and the manures that must be applied, he has, therefore, a far more complex problem than when he is simply asked to examine some given material and report on what he finds. So complex is it, in fact, that he cannot make any useful report solely on the basis of a laboratory investigation, partly because the vegetation relationships of soils are not determined entirely by the nature of the soil but also by its position, subsoil, climate, and other circumstances, and partly because the laboratory methods at present in use are not sufficiently refined to bring out a full account even of that part the soil does play in the matter. But there are certain things the analyst can do.

The soil is to be looked upon as the reservoir from which the plant draws water and food, it must also be sufficiently pervious to allow of the admission of air. As the plant roots possess no power of movement apart from growth and no power of taking in solid particles, it is obvious that the food must be dissolved and that the solution must be capable of movement in the soil, and, further, that the fertility of the soil depends not only on the composition, but also on the mobility of this soil solution. The mobility factor depends on such physical considerations as surface tension, etc., the relation of which to the soil have been only imperfectly studied. Even the composition of the soil solution or of the more soluble part of the soil cannot very satisfactorily be ascertained because there is a continuous breaking down of complex insoluble material, useless as plant food, to simple soluble plant nutrients. The rate at which this decomposition goes on is a very important factor in determining fertility.

In attempting to report on a soil the chemist must therefore consider it from three points of view: its store of plant food, actual and potential; its physical properties, especially those relating to the ease of movement of the soil water; and the rate at which potential food can be converted into actual food.

When the list of plant nutrients had been drawn up by the middle of the last century, it was thought that the problem of soil analysis was solved. The analyst, it was supposed, had only to ascertain what substances were removed in the crop, and he could then recommend their addition as fertilisers, unless the soil happened already to contain them in excess. But this simple view soon proved inadequate: some substances, such as silica, present in large amounts in the crop, were found to possess no fertilising value, while others, such as nitrogen and phosphorus compounds that occurred in the soil in quantities apparently sufficient for many crops, did give marked returns when applied as manure. A distinction was therefore made, in the first instance by Daubeny, between the active and dormant, or, as they came later to be called, the available and unavailable constituents of the soil. Instead of treating the soil with hydrofluoric acid so as to make a complete analysis, or with concentrated hydrochloric acid to break up only the less resistant silicates, the plan was introduced of working with very dilute acids, the solvent action of which should be comparable with that of the soil water, which, in the neighbourhood of the plant roots, is a solution of carbonic acid. Carbonic acid itself does not prove very convenient in the laboratory, and has been replaced by various dilute acids, Dyer's 1 per cent. citric acid being used in Great Britain. Dilute acids give much more useful information about the available supplies of phosphates and potassium salts than stronger acids, but even so the information is still incomplete, for reasons which become evident when the constitution of the soil is realised.

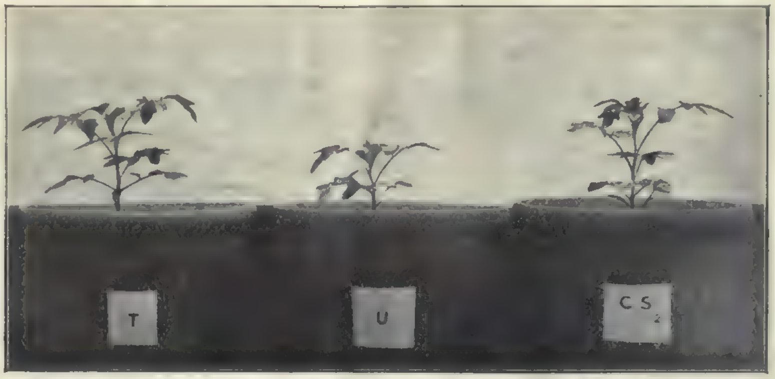


Fig. 1.

The old view of the soil was that it consisted of particles of various sizes derived from the original rock material, the whole being intimately mingled with the decaying fragments of plants. But the recent work of Van Bemmelen, Ramann, and others, has given very strong grounds for the belief that the rock particles are coated with a colloidal complex made up of organic matter, silica, aluminium and iron oxides, phosphoric acid, potassium compounds, etc., which have the power of interacting with and precipitating dissolved substances. When, therefore, soil is shaken up with a very dilute acid, its soluble constituents distribute themselves between the two solvents—the acid and the colloidal complex—so that several extractions are necessary, as Hall and Amos have shown, before all the soluble constituents are dissolved out and no sharp end point is ever reached, because some of the mineral fragments are slightly dissolved.

But the easily soluble phosphates and potash compounds do not represent the whole potential supply. Some is derived from the weathering of the rock particles, but the process is so very slow that it is safest to disregard it altogether as a source of plant food. The realisable supply is to be found in the undecomposed and slowly decomposing plant residues, the roots, stems and leaves of previous generations which slowly break down, returning to the soil what once they took from it.

To an even greater extent these residues form the reserve supply of nitrogenous food materials. Plants can utilise either nitrates or ammonia, but under normal conditions they only get the chance of using nitrates because ammonium compounds are not stable in the soil, but are rapidly oxidised to nitrates by the nitrifying bacteria. Now nitrates differ from other plant nutrients—from phosphates, potassium and ammonium compounds—in that they are not precipitated or absorbed by the colloids of the soil, but are readily washed out by rain water. The analyst is therefore in a particularly difficult position in reporting on the stores of nitrogenous plant food: the nitrates—the actual foods—are entirely ephemeral and their amount at any given moment depends largely on the previous fortnight's rainfall, while determinations of the total nitrogen do not enable any discrimination to be made between material that will decompose in the soil and material that will not, high nitrogen content being equally characteristic of very barren and of very rich soils. Thus, fertile arable soils often contain only 0·15 per cent. of nitrogen, whilst barren heaths, with accumulations of bracken fronds, pine needles, etc., undecomposable in the conditions present, may contain as much as 0·4 or 0·5 per cent., and very rich garden soils may contain the same amount. Here then the ease of decomposition is of fundamental importance. Perhaps the simplest method of comparing the decomposability of the nitrogen compounds in two soils is to keep them under suitable conditions of moisture (*i.e.*, so that they are damp and not sticky), temperature (about 15°) and air supply, for about five or six weeks, and then estimate the amount of nitrate that has been produced during this time. It is possible in this manner to find differences that otherwise escape detection. For example, two soils exactly similar, except that one has received a small dressing of an easily decomposable animal manure and both containing the same amount of nitrogen (·13 per cent., the small addition being quite undetectable), gave enormously different crop returns, as shown in Fig. 3. The soils originally contained 14 parts of nitrate per millim., but when stored under identical conditions one of them produced only an additional ten parts, while the other produced fifty parts. In no other way than this could the difference between the soils have been discovered.

It is not necessary to add an easily decomposable nitrogen compound to increase the supply of nitrates. The same result follows when by any process the soil decompositions are hastened. Calcium carbonate has a very marked effect in this direction. For some reason not altogether clear, it greatly promotes bacterial action and leads to a notable increase in nitrification. Thus, two soils containing equal amounts of nitrogen compounds, but differing in their content of calcium carbonate, may yield up very different quantities of nitrate to the plant. Drainage and improvements in methods in cultivation lead to the same result by increasing the air supply.

All these processes improve the conditions for the organisms already in the soil. But it is possible to alter the flora itself. The soil is inhabited by a teeming population of the most varied kinds of organisms, not all of which are equally useful as makers of plant food. On the whole the spore formers appear to be more useful than the rest, for if the soil is subjected to any method of partial sterilisation there is, as Hutchinson and the writer have shown, a rapid increase in the rate of production of ammonia by bacteria in the soil, which is reflected in the productiveness. Heating the soil to a temperature of 100°C. for one to two hours is the most effective of all methods, because the heat itself leads to some simplification of the complex organic matter and lightens the subsequent work of the bacteria. Marked increases in the rate of ammonia production and in fertility also follow treatment with toluene and carbon disulphide, which appear to have no effect on the dead organic matter, although H. E. and E. F. Armstrong have demonstrated their remarkable action on living cells.

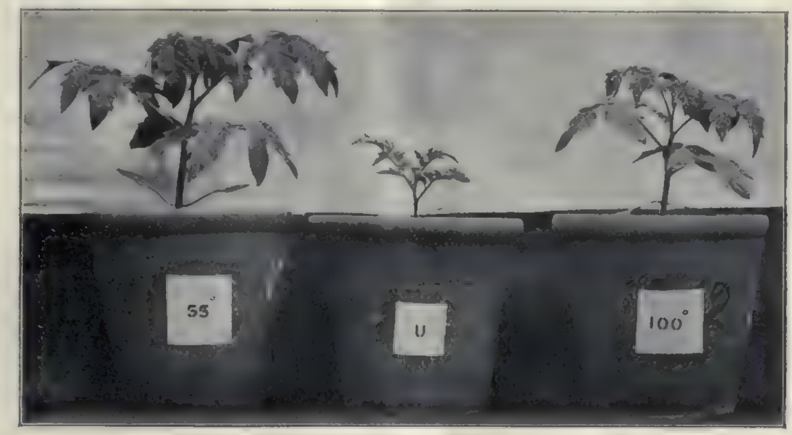


Fig. 2.

Figs. 1 and 2. Tomatoes growing in soils chemically identical but differing only in the efficiency of the bacterial population; in each case the organisms in the partially sterilised soils are more active, and therefore produce more plant food than those in the untreated soil.

U = untreated soil. 55° = soil heated for 2 hours to 55°C. 100° = soil heated for 2 hours to 96°C.

T = soil treated with 0·2% toluol, which was subsequently allowed to evaporate.

CS_2 = " " " 0·2% CS_2 " " "

Fig. 2 shows some young tomato plants grown by F. R. Petherbridge and the writer on untreated and partially sterilised soils, identical in composition according to the ordinary methods of chemical analysis, but obviously differing in fertility.

These considerations suffice to prove that for a complete account of the fertility relationships of soils a chemical examination alone is not likely to lead to any useful result. The analyst must therefore make certain inquiries on the spot designed to ascertain whether the water supply is satisfactory. If it is deficient he may safely recommend the use of dung or other organic manures; if it is excessive he must insist on drainage. In regard to manures and crops he will be well advised to hazard no *à priori* opinion, but to ascertain by inquiry or experiment the actual possibilities of the soil. Fortunately in many counties of England a good deal of information of this kind has already been recorded. Manurial and crop experiments have been carried out on various types of soil, and have shown what are the characteristic manurial requirements and most suitable crops. In such cases the problem of the analyst is considerably simplified. He must first ascertain from the geological map the formation from which his sample of soil has been taken, and then find out from the agricultural college operating over the area, at what centres on that formation experiments have been made and what were the results. If there is considerable diversity in the results, owing to lack of uniformity, lithological or topographical, it is necessary to confine attention chiefly to those centres where the conditions most resemble those in the place under investigation. A sample of soil must be taken from the centre chosen as the standard, and subjected to mechanical and chemical analysis in order to find what differences exist between the standard soil and the soil sent in. If the two soils are practically identical, the analyst will be safe in drawing up a scheme of recommendations based on the results of the field experiments, making any necessary allowances for differences in water supply, etc. But if any great differences are apparent it may be necessary to modify the recommendations, and the following summary will be found useful for this purpose.

Calcium carbonate.—This substance serves two purposes in the soil: it prevents the formation of what are technically known as "sour" conditions, and it flocculates clay. A fair quantity is necessary in loams or clays where the clay fraction in the mechanical analysis exceeds 15 per cent., and the analyst will be justified in recommending dressings of lime, chalk or basic slag, even if 0·5 per cent. or more of calcium carbonate is already present. But where the clay falls below 15 per cent. the need for lime becomes less, especially in regions where the rainfall is not excessive. In sandy soils very small quantities—even ·05 per cent.—sometimes suffice, especially where the soil receives an underground drift of calcareous water.

No general rule can be laid down, but before the analyst recommends lime or chalk on a sandy soil (the clay fraction not exceeding 8 per cent.) he should satisfy himself that acid indicators like finger-and-toe, spurry, etc., are present, and before he states that lime is not necessary on a clay soil he should be quite sure that further additions would have no beneficial flocculating effect.

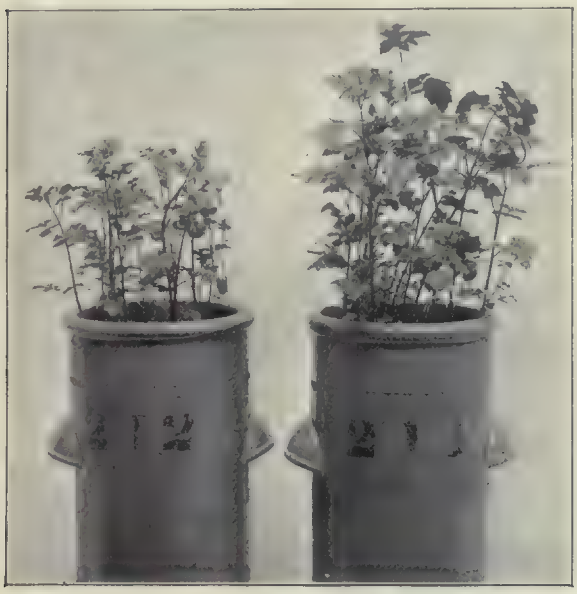


Fig. 3. Mustard growing in soils indistinguishable by ordinary chemical analysis and differing only in the decomposability of the organic matter. The more fertile soil contains some easily decomposable vegetable matter, but the percentage of nitrogen is not appreciably affected thereby, being raised only in the third decimal place.

Potash.—In deciding whether or not sufficient potash is present attention must be paid to the soil, the crop, and the rainfall. Thus, chalk soils, sandy soils, and soils rich in organic matter are peculiarly responsive to potassic manures, whilst clay soils, as a rule, are not. Sugar-making crops like mangolds and sugar beets, starch producers like potatoes, and leguminous crops almost invariably require more potash than they find in the soil. Potassic manures also tend to lengthen the life of the plant, and they therefore prolong the growing period and increase the yield in dry districts where the conditions all tend to early stoppage of growth. ·015 per cent. of "available potash" (Dyer's method) will commonly suffice where the rainfall is thirty inches or more, but not where it is twenty-five inches or less.

Phosphoric acid.—Many soils in our country are insufficiently supplied with phosphates, and it is nearly always safe to recommend dressings of phosphates in regions of high farming even where ·015 per cent. or more of "available phosphoric acid" is present, excepting perhaps on light soils sufficiently provided with moisture and a forward climate. Swedes and turnips among arable crops, and old pastures, seem particularly to need phosphates. Both in dry and in moist situations phosphates are useful. In the former they enable the roots to strike deeply into the moist subsoil, in the latter they stimulate the vital processes going on at the end of the season and thus hasten ripening in cold, wet districts. Rainfall and water supply determine the choice of phosphates; basic slag should be recommended in wet places, and super-phosphate in dry ones.

These considerations will enable the analyst to interpret marked differences between his own soil and the standard soil from the same formation and region. If he is so unfortunate as to receive samples from some formation on which no experiments have been done, he cannot give a very definite report, but will find it best to draw up and recommend a scheme of experiments, based on his deductions, to ascertain whether the properties of the soil dominate the situation, or whether they are obscured by some other factors. Few problems are more interesting than those presented by soil analysis, because each case requires thinking out on its own merits, and in few directions is there more scope for useful original work.

Curing of Tobacco.—It has long been known that this process could be materially altered and controlled by external means.

It has been recently stated that a process has been perfected in Germany whereby the wild ferments are first destroyed by electrical sterilisation and then the required mould is introduced.

In this way superior results are claimed, and the aroma and flavour improved. It is possible that this may be so, as the process as it stands may be compared with that used in the control production of butter. On previous occasions, the preliminary sterilisation of the tobacco has been absent.

Slag and Portland Cement.—Recent improvements in detail seem to indicate that there is a distinct future for a cement which contains 10-20% Portland cement and the rest blast furnace slag. This cement, which may also contain a small proportion of gypsum, is entirely different from the original one which contained say 70 parts of ground slag and 30% hydrate of lime.

The Prussian Ministry has already defined a mixture of 70% Portland cement and 30% ground-dried blast furnace slag, as equal to pure cement. With slag which has been cooled rapidly superior results are obtained. This matter is one which demands more attention in this country

Sulphate of Ammonia.—The manufacture of sulphate of ammonia began on a moderate scale in America in 1893 with the erection of by-product coke oven plants. A number of these have been built, many of which are successfully converting the ammonia into sulphate. The usual recovery of sulphate from coal is about 1 per cent. of the weight used; so that for the production of 5 tons of sulphate per day 500 tons of coal must be carbonised. There are few coal-gas plants of this daily capacity in the United States; but most of the by-product oven plants exceeded it. The United States is now third among the nations of the world recovering ammonia from coal; and though the output was not as yet one-third that of England or Germany, the potential production is nearly as great as that of those countries together. 74 per cent. of the estimated production of sulphate of ammonia in the United States last year came from by-product coke ovens.

The Recent Progress of Organic Chemistry.

By Arthur Clayton, D.Sc., A.R.C.S.

The Resolution of Ethyl Acetoacetate.

Since its discovery in 1863 by Geuther, and independently by Frankland and Duppa two years later, ethyl acetoacetate has remained in the forefront of those substances which offer problems of interest to the organic chemist. It is perhaps hardly an exaggeration to say that excepting benzene, no single carbon compound has been more fruitful in the development of theories concerning molecular structure and in the elaboration of synthetical processes, than the material under discussion. It is little short of remarkable that a compound which has focussed the attention of chemists during nearly fifty years should have yielded within the last few months important information respecting its constitution. This outcome may be claimed as an addition to the results of low temperature research. For a long time ethyl acetoacetate has been regarded as a mixture of two tautomeric modifications in the dynamic equilibrium represented by the expression

$$CH_3 \cdot CO \cdot CH_2 \cdot CO_2Et \rightleftharpoons CH_3 \cdot C(OH) : CH \cdot CO_2Et ;$$

but hitherto the isolation of each component has baffled the skill of chemists. The difficulties connected with this operation have now been overcome by Knorr and his collaborators,(a) who have taken advantage of the relative insolubility of the ketonic modification in certain organic solvents at low temperatures.

For the isolation of the ketone from the equilibrium mixture, a sufficiently concentrated solution of ordinary pure ethyl acetoacetate (equilibrium mixture) in alcohol, or in alcohol mixed with ether, is cooled to −78°C. by a mixture of solid carbon dioxide and ether, in apparatus specially designed to exclude moisture and to maintain high vacua. Under these conditions the ketone separates in well-defined needles or prisms, which, after filtration and washing with petroleum ether, are dried in vacuo, the temperature being maintained at −78°C. Unless warmed, the substance is stable, and even at ordinary temperatures several weeks must elapse before equilibrium is established. The ketone solidifies sharply at −39°C. and boils at 39-40°C. under a pressure of 2mm., small quantities distilling at this pressure without appreciable change. Ferric chloride, which usually produces a deep colour with enolic compounds, but none with ketones, develops with this substance at ordinary temperatures a well-marked coloration, which appears but slowly at −78°C. The development of this colour is attributed to enolisation induced by the ferric chloride, as it is known that this agent very greatly increases the proportion of enolic ester when added to the equilibrium mixture.

In order to isolate the enolic ester, ethyl acetoacetate is suspended in light petroleum cooled to −78°C. in a specially constructed apparatus, and gaseous hydrogen chloride is passed through the liquid in quantity just insufficient for complete decomposition. After filtration, the petroleum is evaporated in vacuo at −78°C., moisture being carefully excluded.

Thus obtained, the enolic ester is a colourless oil, solidifying in liquid air to a glassy mass which soon becomes crystalline. It possesses a pleasant fruity odour, and in small quantities can be distilled in a high vacuum practically unchanged, boiling under these conditions at about 33°C. With ferric chloride an intense coloration is produced even at −78°C., thus showing the enolic nature of the substance. Like the ketone it is apparently quite stable until allowed to acquire the temperature of the laboratory, when it passes into the equilibrium mixture during a period of ten to fourteen days. At 100°C., however, the transformation is complete in one minute, whilst the rate of change is enormously increased by acids or bases, which effect the alteration in a few seconds. Dissolution in organic media also increases the velocity of transformation.

The physical properties of the ketonic and enolic esters, and of their equilibrium mixture, are summarised in the appended table:—

Table 1.

	Enol.	Ketone.	Equilibrium Mixture.
Boiling point at 2 mm.	40–41°C.	33°C. (approx.)	39–40°C.
Freezing point	−39°C.	——	−45 to −43°C.
$n_D^{10\,(b)}$	1·4225	1·4480	1·4230–1·4232

In order to determine the proportion of enolic ester in ordinary ethyl acetoacetate, a number of mixtures containing definite proportions of the two modifications have been prepared and their refractive indices observed (see Table 2), whence it appears that the equilibrium mixture ($n_D^{10\,(b)} = 1{\cdot}4230$) contains 2 per cent. of the enolic ester.

Table 2.

Enol per cent.	n_D^{10}
0	1·4225
2	1·4230
25	1·4287
50	1·4352
75	1·4417
100	1·4480

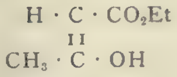
(a) *Berichte*, 1911, Vol. 44, p. 1138.

(b) n_D^{10} is the refractive index for the *D* line at 10°C.

This proportion has been shown to be constant between −78°C. and 181°C. Somewhat similar results have been recently obtained by Kurt Meyer,[c] who employed purely chemical methods of investigation.

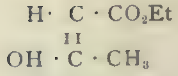
In the vaporous state, however, the proportion varies with the temperature and the pressure; thus distillation at ordinary pressures yields a distillate containing 10 per cent. of the enolic form, whilst by slowly distilling under reduced pressure and rapidly cooling the vapour to −78°C., a distillate containing 22-39 per cent. of the enol is obtained. This behaviour is attributed to the greater vapour pressure of the enolic modification, which distils before the ketone and so continually disturbs the point of equilibrium.

From the probable constitution of the sodium derivative the pure enol is considered to have the *cis*-configuration (1).



$$\begin{array}{c} H\cdot C\cdot CO_2Et \\ \| \\ CH_3\cdot C\cdot OH \end{array}$$

1.



$$\begin{array}{c} H\cdot C\cdot CO_2Et \\ \| \\ OH\cdot C\cdot CH_3 \end{array}$$

2.

On the other hand the enolic ester present in freshly distilled ethyl acetoacetate (see above), which displays an abnormally high rate of ketonisation, is supposed to possess the *trans*-configuration (2). This conclusion is in agreement with the fact that ketonisation of the latter form would be a simpler process.

The refractometric study of the constitution of ethyl acetoacetate possesses the advantage of dealing with the substance apart from chemical agents which might possibly disturb the point of equilibrium. With improved knowledge of the relations between physical properties and chemical structure, it is becoming increasingly evident that those branches of chemical investigation, having for their object the elucidation of constitutional problems, will draw more and more widely upon physico-chemical methods of inquiry.

(*c*) *Annalen*, 1911, Vol. 380, pp. 212-242; *Berichte*, 1911, Vol. 44, p. 2718.

PROGRESS IN BIO-CHEMISTRY.

By A. Harden, D.Sc., F.R.S.

The commonly accepted ideas as to the extent of the power of fermentation possessed by yeast have recently undergone a considerable extension. Whilst it has long been known that yeast can acquire the carbon necessary for its growth from a great variety of substances, it has been at the same time recognised that its power of producing alcoholic fermentation was much more limited, extending only to the decomposition of the hexoses, glucose, fructose, mannose and galactose, and possibly of the synthetic sugar nonose and the isomeric sugars containing three carbon atoms which are present in glycerose.

It was then, some seven or eight years ago, demonstrated by Felix Ehrlich in a series of masterly researches, that side by side with this well-known alcoholic fermentation of the sugars there was taking place another change, termed by him "the alcoholic fermentation of the amino-acids," which resulted in the liberation of ammonia, assimilated by the yeast, and the production of carbon dioxide and an alcohol containing one carbon atom less than the original amino-acid:

$$R.CH(NH_2).COOH + H_2O = NH_3 + CO_2 + R.CH_2.OH.$$

This reaction is only effected by yeast, which is at the same time fermenting sugar, and appears to constitute the change by means of which this organism obtains its nitrogen in an assimilable form.

The mechanism of this reaction was then further investigated by Neubauer and Fromherz (1911), with the result that the intermediate formation of a ketonic acid was rendered highly probable:

$$R.CH(NH_2).COOH + O = R.CO.COOH + NH_3.$$

It was, in fact, found that the *a*-ketonic acids are decomposed by yeast under the same circumstances as the amino-acids (*i.e.*, during the simultaneous fermentation of sugar), and with the formation of the same carbonaceous products.

The unexpected observation has now been made by Neuberg, in conjunction with several other workers, that many, but not all, races of yeast can decompose *a*-ketonic acids quite readily, and in the absence of sugar, with evolution of carbon dioxide and formation of an aldehyde:

$$R\,CO.COOH = R.CHO + CO_2.$$

This process, attributed by Neuberg to the presence of a specific enzyme, carboxylase, has been carefully studied with pyroracemic acid and oxalacetic acid, and the resulting acetaldehyde both isolated and estimated.

$$CH_3\,CO.COOH = CH_3.CHO + CO_2.$$

Pyroracemic acid.

$$COOH.CH_2.CO.COOH = CH_3.CHO + 2CO_2.$$

Oxalacetic acid.

The alkali salts of the acids are also decomposed with production of a carbonate and the aldehyde, part of which in this case undergoes condensation, owing to the increasing alkalinity of the mixture. The reaction with a 1 per cent. solution of pyroracemic acid is almost as rapid as with a sugar solution, and can easily be demonstrated as a lecture experiment.

Many other *a*-ketonic acids have been found to yield carbon dioxide when treated with yeast, although the production of an aldehyde in these cases has not yet been demonstrated. Indeed, judging from the results so far obtained by Neuberg, the decomposition of organic acids by yeast appears to be the rule rather than the exception, and the observations when completed cannot fail greatly to extend our ideas as to the chemical capabilities of this class of organism and to throw a considerable amount of light on many problems concerned with the relation of micro-organisms to carbon compounds.

METALLURGICAL PROGRESS IN 1911.

By G. T. HOLLOWAY.

THE year's record has been one of steady and continuous progress rather than of epoch-making discoveries, but has been none the less important. The intimate connection between chemical industry and metallurgy is particularly well brought out, more especially in connection with electric furnace processes and the production of nitric acid and other nitrogen compounds from atmospheric nitrogen. The use of nitric acid is important, both metallurgically and chemically, and even such materials as calcium carbide and carbamide are of interest in both branches, especially in connection with the recently introduced Clancy process which is now on trial, for the extraction of gold from ores.

Electric smelting is continuously and rapidly modifying our ideas as to the production and purification of alloys, and as to metallurgical possibilities generally. Alloys which were merely objects of interest a few years ago are now manufactured by the ton, and many metals which, as manufactured up to two or three years ago, were brittle and impossible to work, such as metallic tungsten and tantalum, are now obtained in a state of purity which permits of their being worked almost as easily as the precious metals. In this connection, the use of drawn wires of tungsten and tantalum in electric lamps is of most importance, but the introduction of vessels of tantalum for chemical operations is of more than passing interest, as the metal is unattacked by any acid except hydrofluoric, and the vessels may be employed for dissolving substances in aqua regia. The platinum cups used for "parting" in the assay of gold bullion are likely to become replaced by tantalum, which is already in use for surgical instruments where absence of corrosion and ease of cleaning are important. It is not unlikely that other "rare" metals which, by the way, are found to be much less uncommon than was thought before the prospector became acquainted with the uses and value of the minerals containing them, will find curious and unexpected applications. Such has indeed already proved to be the case in connection with pyrophoric alloys containing metals of the cerium group, whose rarity was less marked than the absence of any demand for them until the cigarette smoker came to the rescue with a demand for a rapid means of "lighting-up."

In connection with the metallurgy of iron, the use of rare metals such as molybdenum, tungsten, tantalum, niobium, and even zirconium and uranium, is increasing. The metals are employed as such or in alloy with iron, copper, etc., and their action is still the subject of speculation. The metal titanium has experienced a larger increase in use for steel-making than any other metal, and titanium steel has now, in the United States at any rate, a larger output than all other "special" steels, the output being three times as great as nickel steel, which stands next in importance. It is, of course, incorrect to include titanium among the rare metals, although its use as a metal is of comparative recent birth, and the use of the term "titanium steel" is somewhat of a misnomer, as the metal is used mainly as a purifying agent and is not found in quantity in the finished steel. Its value is probably due to the fact that it combines directly with nitrogen, and it is interesting to note that, although the valuable qualities of steel made from titaniferous iron ores have been known for the last forty years, the difficulty experienced in smelting them under ordinary blast furnace conditions has, until now, prevented the utilization of the millions of tons which lie idle over large areas throughout the world.

The electric furnace is also coming into use more and more in the smelting and refining of the non-ferrous metals, and promises some success in the treatment of refractory zinc-lead ores. The comparative simplicity of the operations and the ease with which they may be controlled, renders the use of the electric furnace most advantageous where electric power can be obtained at a low price, and in many cases more than counterbalances what, at first sight, appear to be prohibitive power costs.

In the retorting of complex zinc ores, the briquetting of ore before charging into the retorts, is receiving some attention and deserves more. Heavier charges can be employed and the retorts are found to have a longer life. The carbon sponge which remains in the retort after distillation is completed retains metallic lead and ferrous oxide in suspension and minimises corrosion of the retorts, while apparently also acting as a filter which removes much of the lead from the zinc vapour, so that the resultant metal contains about 1% less of lead than would otherwise be the case, and commands a correspondingly higher price in the spelter market.

The rapidly growing inter-dependence between metallurgy and industrial chemistry and, above all, the recognition of the fact by the professional representatives of each branch of technology becomes more evident year by year. The overlapping of the work of the chemist and metallurgist is particularly seen in the improvements which are constantly being made in the recovery of by-products and in the reduction of costs due to the care of those who investigate the processes as well as of those who carry them out. The recovery of by-products, many of which are now obtained because legislative enactments have enforced their removal from waste gases and products, has proved the salvation of many processes of smelting or general metallurgical operations, while gradual reductions in the costs of various stages of treatment have increased the lives of many mines and resulted in the opening or re-opening of many which, a few years ago, were unremunerative. This is specially the case in connection with the precious metals, with the recovery of sulphuric acid from the roasting of pyritic ores, and with the electrolytic purification of copper from whose auriferous "anode mud" large quantities of selenium, among other products, are now obtained. The *average* value of the ore now treated on the Rand is well under 7 dwts. of gold, but ore of half that value is within the possible limits, as the average cost of treatment by seven of the largest companies works out at 13/8 per ton, although the average working costs of fifty-six companies was as much as 17/7. The importance of the industry may be gauged from the fact that over £30,000,000 worth of gold is produced per annum, and that the industry employs about 25,000 white men and over 190,000 natives. The number of tons crushed in 1910 was about 21,000,000, having an average assay value of between 28/- and 29/- per ton.

A saving of a few pence per ton on the costs brings into the ore reserves of a mine a large quantity of hitherto unproductive mineral, and the careful experiments of Mr. H. F. Marriott as to the rise in temperature at different levels, indicates that the depth of about 6,000 feet now attained may be increased to a workable depth of as much as 8,000 feet. The geological structure of the country indicates that the "Banket" from which the gold is obtained, continues to at least that depth in parts, and the introduction of electric power has resulted not only in the possibility of working to these depths, but in an all-round reduction, said to amount to about 50%, in power charges.

The work of the chemist has been essential to the development of the gold industry, and particularly in the cyaniding department which has now practically superseded chlorination, also introduced by a chemist.

It would be correct to state that, but for the cyanide process, the Rand would be non-existent to-day as a commercial enterprise, although the actual working at the present day and future improvements are mainly engineering problems.

The good work which is being done by the Institute of Metals, one of the youngest of our societies, and one which has been formed to deal mainly with the non-ferrous metals after they have been reduced to the metallic state by the smelter, is deserving of special mention, and it is interesting to note that the first exhibition dealing with the "non-ferrous" metals will be held in London in the spring. The importance of the non-ferrous metals in both metallurgy and chemical industry, as well as in all branches of engineering, and the enormous output of these metals and their alloys will be thus brought prominently before the notice of both specialist and every-day user, and will doubtless lead to further development in the production and employment of certain special alloys of which one hears so much but knows so little.

Among other matters to which, at the present time, the metallurgist is especially devoting attention, after the metals have actually been won from their ores, may be mentioned the introduction of new acid-resisting alloys for dissolving and evaporating purposes and for pumps, valves, etc., the production of light alloys of high tensile strength for aeroplanes, motor-cars, philosophical instruments and innumerable other uses, the manufacture and introduction of new uses for special alloys which, like silica glass, have no co-efficient of expansion or which can be so compounded as to possess any required expansibility, and of solders which the inventor always hopes, often believes and invariably states, will adhere permanently to aluminium and its alloys.

NOTES OF MEETINGS, &c.

SOCIETY OF CHEMICAL INDUSTRY.

FORTHCOMING PAPERS.

LONDON SECTION.—January 8th, 1912. (1) C. T. Kingzett and R. C. Woodcock. "The Production of Formic and Acetic Acids by the Atmospheric Oxidation of Turpentine." (2) W. P. Dreaper and W. A. Davis. "The Relative Adsorption of Dyes by Sand and Natural Fibres." (3) C. Davis and J. L. Foucar. "Rapid Volumetric Method for the Determination of Free Sulphur."

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THE FARADAY SOCIETY.

AT the last meeting, held on Wednesday, December 6th, 1911, the following Papers were read:—"A Redetermination of the Density and Coefficient of Linear Expansion of Aluminium," by F. J. Brislee, D.Sc.; "The Solution Volumes of Nitric Acid," by V. H. Veley, F.R.S.; "The Influence of the Physical Condition of Metals on Cathodic Over-voltage," by J. N. Pring, D.Sc., and J. R. Curzon, B.Sc.; "Notes on Thermostats," by Professor Hugh Marshall, D.Sc., F.R.S.; "Notes on Two Thermo Regulators," by W. R. Bousfield, M.A., K.C.; "Notes on Thermostats and Devices used in connection with Thermostats," by A. C. Cumming, D.Sc. Dr. T. M. Lowry exhibited Silica Mercury Lamps for spectroscopic and polarimetric work. Mr. W. R. Cooper exhibited the Benkö Primary Battery.

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THE INSTITUTE OF CHEMISTRY.

The recent published appeal for further subscriptions to the Buildings Fund for a new home for the Institute, which will include larger meeting rooms, a library, examination rooms and laboratories, draws attention to the important part this Institution plays in the general advance of Chemistry.

The fact that no fewer than seventy candidates presented themselves for examination in June and July, is most satisfactory. The new building and fittings is estimated to cost about £15,000, and the preparation of the plans will be commenced during the next year. Already contributions and promises to the extent of over £8,000 have been received.

The list of contributors include the names of the great City Companies, as well as firms and individuals not directly connected with the Institute.

In common with other Chartered Societies, the Institute has to fulfil functions in the service of the public under a Royal Charter, and the entrance examinations have been raised to a high standard of practical efficiency. There can be little doubt that this has exercised a wide influence on the progress of scientific education.

* * *

THE INSTITUTE OF METALS.

Arrangements for London Meeting.

The London Meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., on Tuesday, January 16th, and Wednesday, January 17th, 1912. The Meeting will commence on Tuesday afternoon, when the President-Designate (Professor W. Gowland, F.R.S.) will deliver his Inaugural Address on the subject of "Copper and Its Alloys in Early Times." The whole of Wednesday, January 17th, will, if necessary, be devoted to the reading and discussion of a number of extremely interesting Papers, amongst which may be mentioned the following:—"Properties of Certain Copper Alloys at High Temperatures," by G. D. Bengough, M.A.; "Further Experiments on the Inversion at 470° C. in Copper-Zinc Alloys," by Professor H. C. H. Carpenter, M.A., Ph.D.; "The Influence of Oxygen on Copper containing Arsenic or Antimony," by R. H. Greaves; "The Nomenclature of Alloys," by Dr. W. Rosenhain, B.A.; "Poisoned Brass, and Its Behaviour when Heated in Vacuo," by Professor T. Turner, M.Sc.; and a Paper by Dr. Carl Benedicks, of the University of Stockholm, dealing with some novel experiments on a zinc-antimony alloy. The latter Paper, the second to be contributed by a foreign Member of the Institute in the past three months, will be unique in the literature of British Learned Societies, as it will contain illustrations in colour reproduced by autochrome (natural colour) photography.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

CELLULOSE AND CELLULOSE PRODUCTS.

By C. F. Cross.

The term "cellulose" to the chemist rather connotes a highly specialised corner of modern science and industry, than a domain of world-wide dimensions and importance.

Taking the subject on the narrower estimate we may record a few leading impressions of progress. In the pure science of the subject, Professor Ost, with L. Wilkening, has carried the hydrolytic resolution of the normal (cotton) cellulose to extreme limits, which appear to him to warrant the conclusion that it is resolved quantitatively to dextrose (*Chem. Ztg.*, 34—461).

The authors, however, we think, would admit that the evidence is not complete, though much advanced by their work.

"Acetolysis" is another mode of resolution with a well-defined end-product, cellobiose (acetate), which is being studied by various investigators. This method has the advantage of general application to complex carbohydrates and therefore of giving a basis of parallel investigation, as *e.g.*, a comparison of starch with cellulose (W. Schliemann, *Ann.* 378 (1911) 366.)

The formyl derivatives of cellulose present features of exceptional interest. An investigation of typical products has shown several probable complications of the attack of the anhydrous acid: esterification being attended by constitutional modifications of the cellulose complex, and a possible interaction as HO.HC/O, a suggestion taken from another field of observation. The acid appears to react with resorcinol to give a hydroxylated diphenyl carbinol, or benzhydrol, and this suggests a general idea of carbohydrate synthesis, by way of the characteristic residue—CH.OH—with a direct bearing on the fundamental problem of plant physiology, the course of assimilation in the plant cell (*J. Chem. Soc.*, 99, *1450*, 1911).

The hypothesis of a formaldehyde synthesis of carbohydrates, though plausible, has little objective foundation, and leaves out of account the formic acid stage of the deoxidation of CO_2 as well as the question of the relationship of the carboxylic acids generally to assimilation.

In the important sphere of industrial developments the formation of the Internationale Celluloseester Gesellschaft in Germany, represents the fusion of powerful interests, viz., the well-known and highly successful Glanzstoff Co., based on the cuprammonium solution of cellulose, and the German viscose industry and interests, which are in the hands of Fürst von Donnersmarck.

The fusion involves industrial rearrangements: the ester developments are concentrated at Sydowsaue, and the spinning developments of viscose transferred to the Glanzstoff factories.

This fusion follows a parallel consolidation of cuprammonium and viscose industries in France, as a result of which there is a further displacement of the cuprammonium "silk" or Glanzstoff by the viscose product.

It may also be noted that as a result of competitive evolution the collodion process is now being eliminated.

An important development of the viscose industry is the production of film in continuous length. This achievement is due to the Blanchisserie et Teinturerie de Thaon, one of the largest industrial corporations of France. The film is produced at one metre width and down to 0·01 mm. thickness.

Taking the specific gravity of cellulose in this form (transparent colloid) at 1·520, it will be noted that this means a weight of about 15 grams per square metre.

The progress of the science and technology of the subject is well illustrated by recent monographs. Professor Schwalbe, of Darmstadt, has produced a text-book, in two volumes, of the chemistry of cellulose which is a very complete record of progress in the science of the subject. E. C. Worden has also published a manual, "Nitrocellulose Industry," equally important as a technological record, covering industrial applications not merely of the nitric esters, but of the other derivatives of cellulose, which assume plastic forms under suitable treatments. We note also "Wood Pulp and its Uses" (Constable), reviewed on page 31 of this issue.

Progress is shown by the continued activity of the German specialists' association, the Verein Zellstoff und Papier Chemiker, whose published records are of growing importance; and in this country much is to be expected of the recently founded Textile Institute (Manchester) which has already broken ground in investigating the much neglected subject of the relation of spinning quality (of cotton fibre) to proximate chemical composition.

LIME-SILICA BRICKS.

By Walter C. Hancock, B.A. (Cantab), F.I.C.

The wide distribution of silica in nature and its high fusibility combine to offer considerable attractions for its application, not only to ordinary building material, but also to refractory purposes. Sand is the cheapest and most easily handled form in which silica occurs, and much attention has been given to the problem of cementing the grains together in a satisfactory way to yield a useful brick. Although almost any kind of sand may be used, the material selected should be fairly free from iron. The physical character of the sand is of considerable importance in regard both to the size and shape of the grains. A sand composed of fairly thin, sharp-angled grains should be selected, as these present points at which the chemical reactions involved in the cementing and hardening processes can most easily take place. The relative sizes of the component grains exert a marked effect on the properties of the product. Generally speaking, all the grains used pass a sieve of 20 meshes to the inch, and a portion of them, varying from about one-tenth to one-fifth, passes a 150-mesh sieve. With some such mixture as this the tensile strength appears to increase as the amount of fine material is increased, while the crushing strength decreases, so that the selection of the most suitable mixture depends partly upon the uses to which the bricks are to be put. Dolomitic lime may be employed, but on the whole a rich calcium lime seems preferable, and about 5 per cent., calculated on the weight of the sand, is used as the cementing material. The thoroughly burnt lime is either slaked separately and added to the sand, or else mixed with the sand and sufficient water added to the mixture to slake the lime and render the mass plastic enough to be moulded, which is carried out either by hand or by mechanical presses. By mere exposure to the air the slaked lime slowly absorbs carbon dioxide and thus cements the sand grains together, but a more efficient process is to expose the bricks to the action of the gas in a closed vessel under pressure. In this way a re-constructed sandstone with calcium carbonate as a binding material is obtained. The presence of moisture, however, modifies the character of the cementing material, and tends to the production of a hydro-silicate by interaction between the slaked lime and the sand grains. This hydro-silicate, in place of the simple carbonate binder, is claimed to be so much stronger that as a rule after moulding the bricks are introduced into a closed vessel and exposed to the action of steam under pressure for a length of time, depending upon the pressure employed. Bricks of this description are fire-resisting and sufficiently strong for ordinary building purposes, and it is claimed that they are cheaper than clay brick, are hard, uniform and capable of resisting the action of weather and frost. In the United States the manufacture was begun in 1901, and six years later there were about ninety plants at work, the total value of the product amounting to about a million dollars.

Turning now to the use of silicious materials for refractory purposes, natural sandstones, obtained in many cases from the Millstone Grit formation, have been employed in certain metallurgical furnaces, but besides being liable to crack are costly to work. Ganister is a highly silicious sandstone, but the cementing material in that case is clay, and when fired yields a stronger product than silica bricks with a calcareous binding agent. Dinas bricks are made from the well-known rock occurring in the Vale of Neath, by the addition of about 1 per cent. of lime and a little water, and contain about 98 per cent. of silica. The crushed rock is mixed with the lime and water and moulded by hand into bricks, which are dried upon steam-heated floors, and fired to about 1200°C. to 1400°C. in kilns, generally of the down-draught type, which must be cooled very slowly to avoid cracking the articles burned. The firing produces very considerable changes in the mass, and adds greatly to the strength of the bricks. On account of the firing the cementing material in Dinas bricks obviously differs from that found in ordinary lime-silica bricks, which have been hardened merely by the action of carbon dioxide or steam under pressure, and consists of a slag or glass composed of ferrous, calcium, magnesium or aluminium silicates. It is well known that Dinas bricks expand considerably on heating, and that in consequence the tie-rods of furnaces must be loosened as the temperature is raised. For a long time this expansion was attributed either to the expansion of bubbles of occluded gas in the bricks or to the expansion of solid bodies in general under the influence of heat. Neither of these views, however, seemed sufficient to account for an increase in volume of perhaps 24 per cent., and a more satisfactory explanation has been arrived at as the result of some recent work on the subject. From the microscopical examination of thin slices of Dinas bricks that have been exposed for a long time to the action of heat in a furnace, it has been found that the mass consists of a number of crystals embedded in a groundwork of slag or glass. These crystals, however, are not ordinary quartz, but another modification of silica, probably tridymite. The slag appears to play an important part in bringing about this change, and at about 145°C. dissolves the more easily soluble quartz and the less easily soluble tridymite separates out from solution. Further, the conversion of the silica from one form into the other is accompanied by a decrease in specific gravity from 2·65 to 2·33, and an increase in volume of about 20·7 per cent. The quartz grains often exhibit small cracks from which the process seems to extend, and in some cases the cracks may expand until the crystal splits into a number of small grains. There seems no way of preventing this change in the silica, so, for the safety of the product in use, it should be completed during manufacture by thorough firing, for if bricks, in which the change has not occurred, are subjected to sudden heating, or the action of a strongly oxidising flame, the increase in volume may cause them not only to swell but to become spongy and fall to pieces.

In spite of these difficulties, which can be easily overcome by careful supervision in manufacture and in use, the claims of silica bricks for certain refractory purposes are too well established to be lightly set aside, whatever the value of the unfired lime-silica bricks may prove to be for building purposes.

OILS, FATS, AND MILK PRODUCTS.

By Cecil Revis and E. R. Bolton.

Though somewhat ancient history now, the official report on the margarine poisoning cases in Hamburg is of some interest as showing how easily poisonous fats may be passed for edible purposes, and incorporated in food products. The fat in question, which was one of the Chaulmoogra group, came under the notice of one of us in this country, and had it not been recognised, would have been used here for a similar purpose.

Among interesting oil products which may prove of some importance in the near future, are a substitute for boiled oil made from the oil of the Soya bean—which oil, up to three or four years ago, was scarcely known in this country—and also Para Rubber Seed oil, which, owing to the extensive planting of rubber, is likely to be, sooner or later, put on the market in considerable quantities, and will form a substitute for linseed oil.

An extremely useful bulletin has been issued by the United States Dept. of Agriculture, on the action of edible fats and oils on various metallic containers, and these results will be a help to the hard-worked technical chemist, who seldom has time to go into these matters so thoroughly. The metals least attacked seem to be aluminium, iron and tin, in the order named.

The search for the philosopher's stone which would convert liquid fatty acids and oils into solid fatty acids and fats, on a commercial scale, has long been sought, and seems at last to have been achieved in a simple catalytic manner, several investigators having shown that palladium in the presence of hydrogen will produce this long desired conversion.

On the analytical side, it may be noted that the Committee on Uniformity of Methods of Analysis in America have suggested certain methods on which they invite criticism. There is no doubt that the standardisation of methods is very useful for international questions, but such standardisation leads, as a rule, to too much complication for ordinary work. Falciola has put forward a method of separating oleic from stearic and palmitic acids based on the solubility of their ammonium salts in alcohol: the method certainly has decided advantages over the ordinary lead-salt-ether method, and if it prove its claim on examination, will furnish a valuable addition to the armoury of the oil chemist. The technique of the estimation of rosin in fatty oils has received a useful modification by Fahrion, who points out that the fatty acids may be esterified by treatment with ordinary concentrated hydrochloric acid in the presence of alcohol and petroleum spirit, thus avoiding the necessity of preparing dry hydrochloric acid gas as in the usual method, and the simplicity of this modification renders it worthy of some attention.

Several investigators have recently drawn attention to the fact that the composition of butter made from the milk of cows fed on beet roots or cocoanut oilcake leads to analytical results which would point to the butter being adulterated with cocoanut oil. This source of error is at the moment more imaginary than real, but the increasing use of cocoanut cake for cattle feeding may lead to some difficulty in the near future. We have no doubt that some analyst will be foolish enough to recommend that the use of cocoanut oilcake should be made illegal as one way out of the difficulty, there being much too unfortunate a tendency to regard the abnormal as adulterated, but such a procedure can only be regarded as a cloak for the weakness of analytical methods.

In connection with butter, a very useful investigation has been carried out by Fischer and Gruenert on the value of various preservatives, with regard to the keeping properties of butter. It is very interesting to note that their results lead them to the conclusion that common salt is to be preferred to all the ordinary chemical preservatives; a finding which must be considered very satisfactory in view of the numerous, and much lauded, but often undesirable substances which are put forward for this purpose. Hesse also has exploded the time-honoured idea that the water content of butter has any connection with its quality.

Working with an old Cheddar cheese, Nierenstein finds in the ethereal extract, besides the fat, cholesterol tetra—and penta—methylenediamine and amino acids, while in Roquefort, Dax has identified tyrosin, and from Swiss and Cheddar cheese he has also isolated p-hydroxy-phenyl-ethylamine, and considers this last to be produced from tyrosin by the action of bacteria.

PHOTO CHEMISTRY.

By C. E. KENNETH MEES, D.Sc.

ABSORPTION PHOTOMETRY.

SCIENTIFIC chemists are making continually more use of physical apparatus, and of physical methods of measurement and analysis, largely because of the extreme rapidity and convenience of those methods. But a method of measurement which has not received from chemists the attention which it deserves, is the photometric measurement of the absorbing power of solutions. Spectrophotometers appear to be used at present almost exclusively in research work; but there seems to be no reason why they should not come into more widespread use in technical chemistry.

The principle on which the spectrophotometer is based is known as "Beer's Law," which states that for homogeneous radiation the light transmitted by an absorbing medium is an exponential function of the mass of the substance present. This may be explained as follows.

Suppose that we have one layer of an absorbing substance with unit light incident upon it, and that it transmits $\frac{1}{a}$ of the incident light, a second layer will transmit again $\frac{1}{a}$ of the light incident upon that, that is $\frac{1}{a^2}$ of the original light. Similarly, a third layer will transmit $\frac{1}{a^3}$ of the incident light, and n layers $\frac{1}{a^n}$. If the thickness of the unit layer be taken such that it transmits $\frac{1}{e}$ of the incident light, where e is the base of Napierian logarithms, then x layers will transmit $\frac{1}{e^x}$. $\frac{1}{e^x}$ is thus the transparency of the substance, e^x may be called the opacity, and x, which is known in physical chemistry as the "extinction co-efficient," and in photography as the "Density," is proportional to the number of unit layers and thus to the mass of the substance. We may define, therefore, the extinction co-efficient as the measure of the mass of the substance, and the same value in photography is proportional to the reduced silver per unit area of a developed photographic plate, and is termed the "Density."

For convenience in technical work and photography, it is usual to use as the unit layer one which absorbs one-tenth of the light, in order to adopt Common instead of Napierian logarithms.

It will be noticed that "Beer's Law" applies only to homogeneous radiation, and a simple photometer can therefore be used only for black substances such as the silver deposit in a photographic plate. If coloured solutions, such as occur in technical chemistry, are to be measured, a simple photometer is not applicable, and a spectrophotometer must be employed.

In form, a spectrophotometer is usually a modified spectroscope, the beam being divided into two portions at the slit, and some method of darkening one of the beams in a known manner being employed, the two fields being placed in juxtaposition in the eye-piece.

(To be continued.)

ORIGIN OF CARBONATE OF SODA IN NATURAL WATERS AND MINERAL DEPOSITS.

By S. RIDEAL, D.Sc., F.I.C.

STARTING from ordinary well-known phenomena; rain water contains a considerable amount of carbonic acid dissolved from the atmosphere, and in passing over rocks or percolating through soils slowly dissolves a portion of their calcareous or magnesian constituents as bicarbonates, causing it to become more or less "hard," according to the nature of the strata. At the same time, independent of the presence of carbonic acid, and simply by virtue of its solvent action as water, it dissolves alkaline constituents of the rock materials. Of these, the chlorides and sulphates, being the most soluble, are first washed away, and appear along with the earthy bicarbonates as ingredients in river waters. The latter, when naturally evaporated, as in inland lakes without outlet, or in the sea—the sea of course being the naturally evaporated residue of all its tributary rivers—a salt water is formed, loaded with the chlorides and sulphates of sodium and magnesium, and giving rise to the "bitter lakes" in various dry regions. A few are known as "soda lakes" from their being strongly alkaline and containing varying amounts of carbonate of soda, which they sometimes deposit in crusts, generally very impure, forming the minerals "trona" and "natron"; or as sediments such as the "urao" found at the bottom of a lake in Maracaibo, South America.

According to Furer, between Wadi Shiati and Germa in Tripoli, there exists a lake called Wadi Trona, from which natural carbonate of soda mixed with common salt is obtained. It seems certain that the *nitre* of the Bible was of such a nature.

As the matters in solution in water increase by evaporation or percolation, there is always a tendency towards the deposition of carbonates of lime and magnesia as incrustations, with a separation of the sparingly soluble sulphate of lime, so that the carbonate of soda which perhaps was originally present only in small quantities, augments in its ratio to the other substances. Such a change may result occasionally in the production of an alkaline mineral water. That of Vichy, for instance, contains about ½ per cent. of bicarbonate of soda, with only ·03 to ·09 per cent. of sodium sulphate, no sulphate of lime, and under a tenth per cent. of lime and magnesium carbonates. An analogous process seems to account for the constitution of waters drawn from the chalk where it is covered with the clay, as in London artesian wells, and also from other porous rocks similarly covered. A number of these cases have been examined by Fisher (*Analyst*, Aug. 1901 and June, 1902). He found that samples of chalk from depths of 500 and 800 feet contained 0·03 and 0·05 per cent. of sodium carbonate, while the Trafalgar Square well water has in solution nearly 19 parts per 100,000 of sodium carbonate with only about 7 parts of lime and magnesia carbonates, but contains also 28 parts of sulphate of soda and 27 of sodium chloride. Some wells in the greensand below the gault clay showed nearly 70 parts of sodium carbonate, 11 of sodium sulphate, 23 to 29 of sodium chloride, and only 3 to 5 of calcium and magnesium carbonates. A core from the lower greensand at Wheatfield yielded to water 0·25 per cent. of sodium carbonate. The deep supplies over a certain area in London, both north and south of the Thames, are of a similar character to that in Trafalgar Square, and in January, 1911, I found an artesian well in Victoria Street to yield 28·3 parts of sodium carbonate, 9·3 of calcium and magnesium carbonates, and 24·6 of sodium chloride. Thus these alkaline waters are always overloaded with common salt, with very few exceptions, such as a well at Skegness which gave me in 1905 22 parts of sodium carbonate with only 3·4 of the chloride; but here different conditions must have been at work, such as I shall presently indicate.

A mutual elimination of lime, magnesia, and sulphates was explained as long ago as 1863 by Hunt in his "Geology of Canada," when he observed interaction of bicarbonate of lime and sulphate of magnesia to form insoluble precipitates of gypsum and of hydrated magnesium carbonate, thus removing at once the lime, magnesia, and sulphate from solution.

But the chloride of sodium is still left, and in nearly all these natural sources (which may be called mother liquors of the washing of rocks and soils) bears such a large proportion to the carbonate of soda that the refining of the latter would cost more than the raw material is worth, so the object is diverted to the extraction of other substances which may be present.

In a few localities, however, deposits and solutions of sodium carbonate which are far purer have been lately discovered at Lake Doroninski, near Chita in Siberia, and at Lake Magadi in British East Africa. A deposit from the latter has been reported to be a sesquicarbonate (the mineral "trona") and to contain only 0·36 to 0·48 per cent. of sodium chloride. I have just examined the products from the Chita site, and have found a deposit there to correspond with the normal carbonate (the mineral "natron"), and to show only a trace of chloride. The water of the Chita Lake has about four times as much sodium carbonate as sodium chloride, with a very small quantity of sulphate, and lime and magnesia practically absent. This liquid, by a simple manufacture, easily yields almost pure soda crystals. The comparative purity of such deposits may be partially accounted for by their having been naturally crystallised slowly, but it must be remembered that crystals formed in strong solutions of other substances are always much contaminated by constituents of the liquor. When they are formed by mere drying up of bodies of water they will be, of course, incrusted with all the impurities.

The low amount of impurities in the water of Lake Doroninski requires a different explanation. One must remember that chalk and a great majority of other rocks are marine strata, and must evidently retain a residue of sea water or of saline matters derived from its concentration. When these are subsequently washed out by the fresh water of rains, the resulting rivers will be a solution of the more soluble compounds in the rocks and soils, and on evaporation will give the brines and bitter liquids that we meet in the salt lakes and in the sea. There would be left behind in the rocks or soils the less soluble constituents, including in many cases large quantities of mineral silicates of the alkalies and other bases, which are attacked more or less slowly by rain water containing carbonic acid. In this solvent action it is observed that soda compounds are, as a rule, more readily acted on than those of potash; instances in point are that ordinary, or potash, feldspar is much more resistant to acids than its sodium analogue albite, also that sodium, while the rarer of the two elements in silicate minerals, preponderates over potassium in water. Such a natural process as I have indicated, followed by sedimentation and evaporation in a lake, would result in an exceptionally pure solution of sodium carbonate like that at Chita. It involves absence of infiltration of chlorides from other sources, and therefore is of rare occurrence.

The decomposition of the silicates in rocks is also elucidated by certain reactions discovered by Dr. Gans and applied by him in the "Permutit" method of purifying and softening water. In the weathering of rocks the anhydrous silicates can combine with water to form a hydrated and less resistant class of minerals, the zeolites, several of which contain silicate of soda united with silicates of other bases. When acted on by water containing carbonate of lime, a transposition occurs, giving carbonate of soda in solution and leaving silicate of lime insoluble. In the treatment of water Dr. Gans uses an artificially prepared zeolite, as more rapid in action, and regenerates it afterwards by the passage through of a solution of common salt, whereby the soda base is restored and chloride of calcium is washed out. The reactions suggest another way by which nearly pure alkali may originate in nature.

A similar interchange between *carbonates* has been observed near the Great Salt Lake, Utah. A hydrated double carbonate of lime and soda called gaylussite, which is sometimes deposited by saline waters, has here formed raised terraces, but the crystals have gradually been changed, by the passage over them of a hard limestone water, into carbonate of lime alone, the soda dissolving in the liquid. If the latter contained little else but the lime carbonate, the resulting soda carbonate solution would be correspondingly pure.

UNIVERSITIES AND COLLEGES.

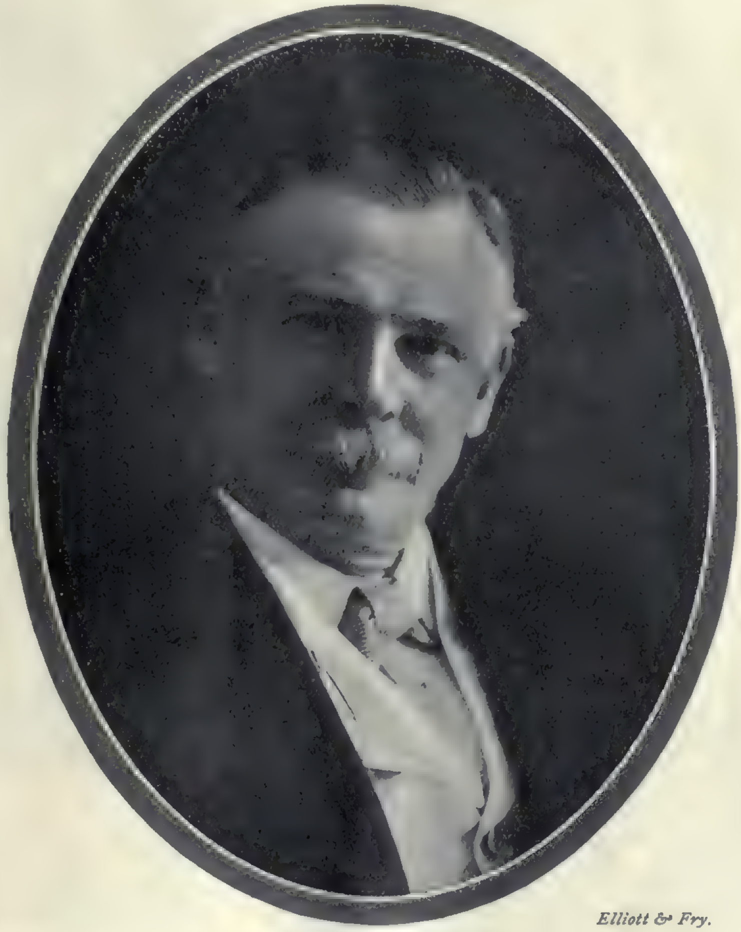
THE CHEMICAL DEPARTMENT OF THE ROYAL COLLEGE OF SCIENCE:

Past and Present.

By JAMES C. PHILIP, M.A., D.Sc.,

Assistant Professor of Chemistry, Imperial College of Science and Technology.

ALMOST seventy years have now elapsed since the sowing of the seed from which the Chemical Department of the Royal College of Science has sprung. As it approaches its three score years and ten, the institution is taking a fresh lease of life, and it may be of interest to many at this juncture to recall the history of the College and the honourable part it has played in the advancement of chemical science.



Elliott & Fry.

SIR EDWARD THORPE, C.B., F.R.S.,
Professor of Chemistry at the Royal College of Science.

The visit of Liebig to this country in 1842 aroused a widespread interest in the application of chemistry to practical problems, notably those connected with agriculture. Convinced of the value of scientific research in this and other directions, a number of public-spirited men, supported by the ever ready sympathy of the Prince Consort, took active steps to establish an institution which should be devoted to the advancement of chemical knowledge. These efforts resulted in the formation, in 1845, of the Royal College of Chemistry, and in the appointment of Hofmann, one of Liebig's most distinguished pupils, as the director of the new institution. Work was begun at temporary quarters in George Street, Hanover Square, and 26 students entered for the first session. A year later Hofmann and his pupils took possession of the new laboratories that had been built on another site attached to 16 Hanover Square. Behind this house there was a large vacant space with a frontage to Oxford Street, and it was on this part of the site that the laboratories were erected.

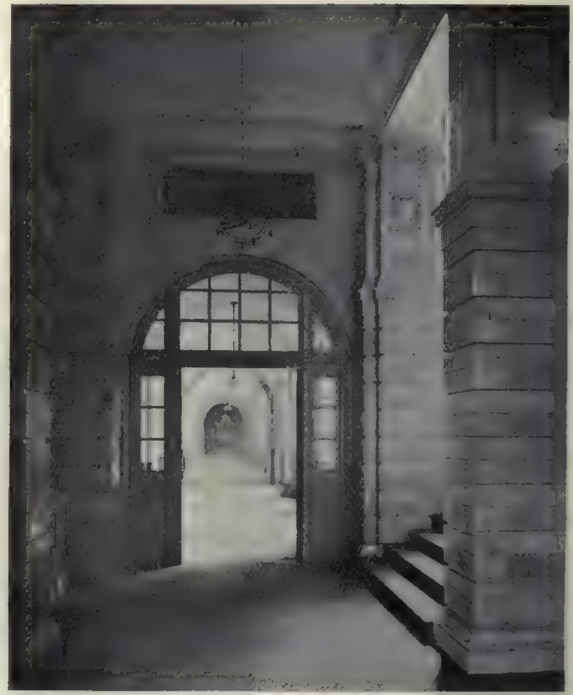
In these early years the Royal College of Chemistry was considerably hampered by financial difficulties. The institution was the outcome of private effort, and there was no State aid available for its support. The enthusiasm for chemical research aroused by Liebig's visit gradually waned, and the authorities found it difficult to maintain the College in a thoroughly efficient condition. It is not surprising, therefore, that when the opportunity offered, in 1853, the College was brought into association with the "Metropolitan School of Science applied to Mining and the Arts." This Government institution, founded in 1851 in connection with the Museum of Practical Geology in Jermyn Street, was under the control of the newly formed Science and Art Department, and provided instruction in chemistry, physics, natural history, geology, metallurgy, mining and mineralogy. It was the resignation of Dr. Lyon Playfair, the Professor of Chemistry in this school, which cleared the way for the affiliation of the Royal College of

Chemistry in 1853. As a result, the College became the chemical department of the Jermyn Street School, and Hofmann succeeded Playfair in the chair of chemistry. The inconvenience of having lectures at Jermyn Street, whilst the practical work was carried on at the Royal College of Chemistry, was finally obviated by building a lecture theatre on the vacant space behind the Oxford Street premises.

In 1857 the name of the Jermyn Street institution was changed to the "Government School of Mines and of Science applied to the Arts," and later, in 1863, to the "Royal School of Mines." All through these changes the work at the Royal College of Chemistry pursued its normal course. The laboratories were filled with eager students, and a regular output of scientific memoirs testified to the zeal and industry of the director and his co-workers.

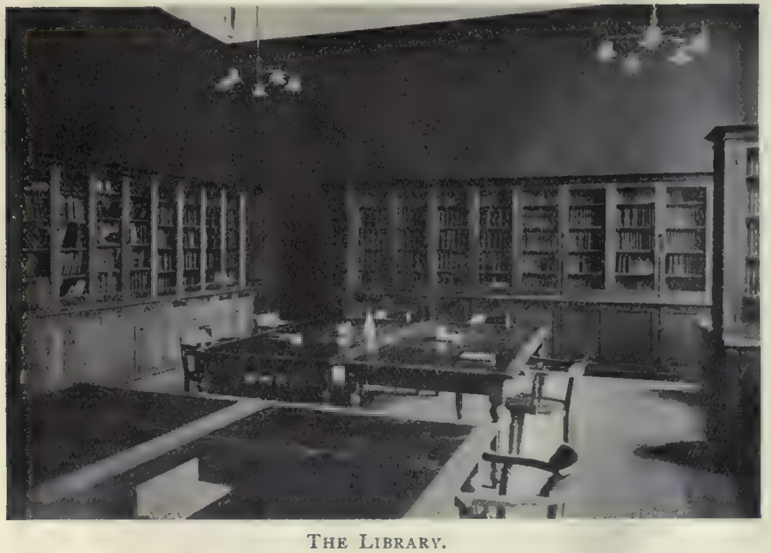
In 1864 Hofmann accepted the invitation of the Prussian Government to come to Berlin as Professor of Chemistry in the University there. His departure was made the occasion of a striking tribute to the energy and success with which he had devoted himself to the advancement of chemical instruction and research in England, and to the admiration and esteem he had won in his adopted country. The position which the Royal College of Chemistry filled in the English scientific world about the middle of last century is shown by the names of some of those who were Hofmann's pupils at one time or another; such were Abel, Bloxam, Church, Crookes, Warren de la Rue, Divers, Groves, Liveing, McLeod, Newlands, Nicholson, Odling, Pavy, Perkin, Tilden, and Valentin.

Hofmann was succeeded by Dr. Edward Frankland, who had already filled chairs of chemistry at Owens College, Manchester, and St. Bartholomew's Hospital. One of the new professor's first duties was to draw the attention of the authorities to the insufficient accommodation at the Royal College of Chemistry. There was room for forty students, but this was no longer adequate, and Frankland pressed for new laboratories. In reports written in 1868 and the two following years he emphasised the need for extension, and expressed the hope that, as the Government had already directed the construction of chemical laboratories at South Kensington, these buildings would be completed with the utmost expedition. The premises in question were primarily designed to house the School of Naval Architecture, and apparently the erection of the chemical laboratories was not originally undertaken with any intention of providing for the growing needs of the Royal College of Chemistry. But the opinion steadily gained ground that these needs would be most adequately met by the complete transfer of the College to South Kensington, and this view received authoritative expression in the first Report of the Royal Commission on Scientific Instruction in 1871.



THE GROUND FLOOR CORRIDOR.

At last, in 1872, the Departments of Chemistry, Physics, Applied Mechanics and Biology were removed to the buildings on the east side of Exhibition Road, South Kensington, the School of Naval Architecture being transferred to Greenwich. The buildings in Oxford Street, after an occupancy of twenty-six years by the Royal College of Chemistry, were handed over to the Office of Works, and at a later date came into the possession of the General Medical Council. Although its union under one roof with other departments of the Royal School of Mines naturally led to the disappearance of



THE LIBRARY.

the Royal College of Chemistry as a distinct institution, a glance into the Reports of the Science and Art Department shows that up to 1878 the College was regarded as an integral part of the Royal School of Mines. Gradually, however, as the other Departments of Geology, Mining, and Metallurgy were transferred to South Kensington, its individuality became merged in that of the composite institution.

An immediate effect of the move to South Kensington was the marked increase in the number of students who entered for the chemical course, and in the following year the laboratories were fully occupied. In the instruction of the students and in the direction of research, the professor had the help of seven private assistants, while there was in addition a lecture assistant appointed officially.

THE ANALYTICAL LABORATORY.

Once again, in 1881, the name of the institution was changed, and it became the "Normal School of Science and the Royal School of Mines." This altered name was, to some extent, the expression of a definite policy, and it was stated that the Normal School of Science was primarily intended for the instruction of teachers and of students of the industrial classes selected by competition in the science schools of the United Kingdom. The conception of a School of Applied Science, apart from mining and metallurgy, which had figured in some of the early titles of the institution, was thus allowed to pass into the background.

In 1885 Dr. Frankland retired. He was succeeded by Dr. T. E. Thorpe, who, for eleven years previously, had been Professor of Chemistry at the Yorkshire College, Leeds. The elaboration of the chemical curriculum, introduced in the years following Dr. Thorpe's arrival, was rendered necessary by the rapid development of the science. Thus, whereas in 1881 there was a course of 20 lectures on inorganic chemistry and a similar one on organic chemistry, the instruction given in 1889 included 60-70 lectures on inorganic, 50 lectures on organic chemistry, and 15 lectures on chemical analysis, while two years later a course of 15 lectures on physical chemistry was added.

The official title of the institution was again changed in 1890 to the "Royal College of Science, with which is incorporated the Royal School of Mines." Unaffected by this change, the chemical department continued to provide preliminary training for all science and mining students, and advanced instruction for those (20-30 annually) who were specialising in chemistry. As at earlier periods, a continuous flow of scientific memoirs emanated from the laboratories of the department.

In 1894 Professor Thorpe was appointed Director of the Government Laboratories, and was succeeded by Dr. W. A. Tilden, from Mason College, Birmingham. Even before this time the need for larger and more up-to-date laboratories for instruction and research was beginning to be felt. The erection of new buildings had ultimately to be faced, and both Dr. Thorpe and Dr. Tilden had a share in the preparation of plans for the coming development. At last, in 1898, it was definitely decided to build new laboratories for physics and chemistry on the south side of Imperial Institute Road. By 1906 these buildings were ready for occupation, and the Chemical Department moved into its new quarters in the early autumn of that year.

Physical Chemistry Laboratory.

While these premises were still in course of erection a Departmental Committee was appointed to inquire into the working of the Royal College of Science and Royal School of Mines. The Committee was instructed to consider how the staff, buildings and equipment of these institutions could be most advantageously used in the promotion of higher scientific studies. In January 1906 the Committee reported in favour of the establishment at South Kensington of an institution where advanced training and research should be provided in various branches of science, especially in its application to industry. It was further proposed that the scheme should include the work of the Royal College of Science, the Royal School of Mines, and the Central Technical College. In July 1907 the "Imperial College of Science and Technology" was incorporated by a Royal Charter, in which the constitution and purposes of the institution were laid down on the lines of the Departmental Committee's Report.

The object of the Imperial College, then, as defined by the Charter and afterwards interpreted by the Governors, is something quite different from the training of teachers, the purpose which the Normal School of Science, afterwards the Royal College of Science, was primarily intended to serve. It is maintained that whilst the Royal College of Science has had a splendid record in its method of teaching pure science and in its promotion of research, the usefulness of the institution will be increased by giving greater prominence both in the courses of instruction and in research work to the industrial application of science. At the same time, the scientific basis must remain and the contemplated alterations must be mainly by way of addition to the existing staff, buildings and equipment.

In the development of the College on its technological side the Chemical Department is taking its share. While the contributions it has hitherto made to the advancement of chemical knowledge—

represented by some 300 published papers during the past forty-five years—have been as a rule of a purely scientific character, many of its students have gone out to occupy important positions in the industrial world. With the increased facilities for advanced work and research offered by the new laboratories already in occupation, and with the provision of instruction in chemical technology, now taking concrete shape, a still more effective training of men for responsible technical positions becomes possible.

The work in the new laboratories in Imperial Institute Road has been organised under the direction, first of Sir William Tilden, and afterwards of Sir Edward Thorpe, the present Professor of Chemistry. In regard both to space and to suitability for higher instruction and research these new premises represent a very marked advance on the old laboratories in Exhibition Road. The chief rooms are a large analytical laboratory with 144 working places, an organic laboratory with accommodation for 40 students, and a smaller physical chemistry laboratory. Photographs of these are published with this article. There are, further, three lecture theatres, one seated for 164 students and the other two holding about 100, a library and a number of smaller rooms for special work and research. The larger size of the department has necessitated an increase in the staff, and this now consists of a professor, three assistant professors, a lecturer, ten demonstrators, and two lecture assistants. The instruction includes courses of lectures on general and inorganic chemistry, on inorganic and organic analysis, on physical chemistry, and on elementary and advanced organic chemistry. Practical work in inorganic, physical and organic chemistry is carried out in the respective laboratories, while a course on photography is available for those students who desire to take it. The first step in the development of the technological side of the department has been the provision of special advanced courses on gaseous fuel and combustion, and on the design and erection of chemical plant. These latter courses are intended for students who have taken the Associateship of the College in chemistry or who have done equivalent work elsewhere.

THE ORGANIC LABORATORY.

Such is the present position of the Chemical Department of the Royal College of Science. If, on these new lines, its reputation for thorough training and active research is fully maintained, it cannot fail to contribute largely to the advancement of British science and technology, and so realise the conception of those far-seeing men who founded the Royal College of Chemistry nearly seventy years ago.

THE PHYSICS AND CHEMISTRY OF COLLOIDS

By EMIL HATSCHEK.

CHAPTER I.

THE first systematic investigation of our subject, and the name "Colloids," are due to Thomas Graham, whose results were published in a number of papers between 1861 and 1864, some of which have recently been republished and included by Wilhelm Ostwald in his series of "Classics of the exact Sciences." His discoveries may be briefly summarised under two heads. In studying dialysis, *i.e.*, the diffusion of dissolved substances through organic membranes like parchment into the pure solvent, he found that some of them passed freely through the membrane into the surrounding solvent, while a number of others failed to do so, or diffused at an extremely slow rate. Generally speaking, the former were bodies which were known to crystallise, while the latter, *e.g.*, glue, gelatine, gum-arabic, etc., were known only in the amorphous condition. Graham accordingly divided soluble bodies into two classes: Crystalloids and Colloids (from *colla*, glue).

The second discovery made by Graham, in prosecuting these researches, was that a number of substances generally considered as insoluble could, by appropriate methods, be obtained in what at first sight appeared to be real solutions. These methods will be referred to later on, but it may be mentioned here that Graham obtained, and very carefully investigated, such solutions of silicic acid, tungstic acid, chromium, aluminium and ferric hydroxide. Most of these appeared to the eye like true solutions, *i.e.*, they were perfectly clear and apparently homogeneous. They did, however, not diffuse through parchment, and on account of this property they were called by Graham "colloidal solutions," or simply "sols," which term has now become generally accepted. These sols showed a further striking peculiarity, which distinguished them sharply from true solutions, such as, say, solutions of sodium chloride or copper sulphate, inasmuch as extremely small additions of electrolytes, and such as did not react at all with the dissolved substances, caused radical alterations in the condition of the solutions. A trace of carbon dioxide, *e.g.*, caused the silicic acid sol to set to a translucent jelly, while a small addition of sodium sulphate would precipitate the ferric hydroxide as a flocculent mass. Obviously these were phenomena quite different from known reactions of a purely chemical nature, and the sols had to be considered as systems differing from ordinary true solutions.

While Graham's investigations were the first ones directed systematically towards the production of sols and the study of their characteristic properties, numerous earlier instances of sol formation, *i.e.*, the production of apparent solutions of substances known as insoluble, are not wanting. Wöhler found in 1839 that silver citrate heated in a stream of hydrogen left a residue which dissolved in water with a red colour; this solution, which he took to be a silver subcitrate, has since been proved to be an impure silver sol. In 1857 Faraday obtained a red liquid by reducing a very dilute solution of gold chloride with a few drops of ethereal phosphorus solution, and expressed the opinion that the gold was suspended in the liquid in a state of extremely fine distribution. In the fifties sols of silicic acid, aluminium hydroxide and ferric hydroxide were prepared respectively by Kühn, Crum and Pean de St. Gilles, and some very much earlier instances have recently been brought to light by The Svedberg, Prof. Walden, and others.

Since Graham's time the whole subject has been studied by an ever-increasing number of investigators, both physicists and chemists, with new methods and appliances, the most important of which has been the "Ultra-microscope," invented in 1905 by R. Zsigmondy and H. Siedentopf, which, even in that short time, has enormously enlarged our knowledge of colloidal solutions. The principal step forward in theory has been the proof, now quite conclusive, that "colloids," in Graham's sense, are not a definite class of substances, but that by suitable methods a very large number of bodies can be prepared in a colloidal condition, which thus presents itself as a *state*, not as *form* of matter. Thus, *e.g.*, sodium chloride is certainly a very well-defined crystalline substance; yet a colloidal solution of sodium chloride in petroleum ether has been prepared by Paal. Most of the metals have been obtained as sols, and the silver and mercury sols may be obtained commercially and are used in medicine. Even the alkali metals have been obtained in the colloidal state by the use of organic solvents, low temperatures and experimental arrangements of great ingenuity. Similarly a large number of sols of oxides, hydroxides and sulphides are known, and especially the latter have been used largely in several classical investigations, to which we shall have occasion to refer later on.

All these sols are laboratory products, prepared by certain well-defined methods and with numerous precautions. They are in general very dilute, rarely containing more than fractions of one per cent., and either quite clear or slightly opalescent. Many of them, *e.g.*, the gold sols, are beautifully coloured and show pseudo-fluorescence, *i.e.*, the colour in transmitted light is different from that in reflected light. They all have one characteristic in common: on addition of varying, but always small, quantities of an electrolyte they undergo a marked and irreversible change, the solid matter being precipitated or the whole liquid setting to a jelly.

In striking contrast to these artificially prepared products there exists a large group of substances, which can be dissolved at once without special methods to form colloidal solutions, and this comprises such important organic bodies as gelatine, albumin, starch, agar, etc. These differ a good deal from one another in their behaviour. Some, like gelatine, form solutions above a certain temperature; when this falls below a limit depending on the concentration, the solution sets to a jelly, which can be "melted" again, and this can be—with certain precautions—repeated. On the other hand, egg albumin is soluble at ordinary temperatures, but on heating coagulates to a mass, which is now insoluble. Gum-arabic, to name a third substance belonging to this class, forms a viscous liquid which does not set to jelly on cooling nor coagulates on heating. Similarly varied is the behaviour of these organic substances towards electrolytes, but they all share with the inorganic sols the one characteristic property of not diffusing through a parchment membrane.

In this class, too, it is not necessary that the solvent should be water, and a number of solutions have lately assumed very great industrial importance in which this is not the case. Thus it is very generally known that cellulose dissolves to a viscous solution in Schweizer's reagent—copper oxide-ammonia—and this cellulose sol is one of the materials used in the production of artificial silk. The solutions of nitro-cellulose in various solvents, such as ether-alcohol, acetone and acetic acid, are equally well known, and form the starting material in the production of artificial silk, photographic films, etc. Recent experiments with solutions of nitro-cellulose in acetone, which were dialysed against pure acetone, have shown that these sols also share the general characteristics of the aqueous sols, inasmuch as they do not diffuse.

In close connection with this property is another quite general feature of colloidal solutions: that they do not show any appreciable osmotic pressure, or, in other words, no raising of the boiling or lowering of the freezing point. Whether this absence of osmotic pressure is due to the large size of their molecules and high molecular weights, we shall have to discuss later in considering the theory of colloidal solutions more in detail.

One other property of colloids, which shows itself particularly strikingly in their "gels"—as Graham called the products obtained by the coagulation of sols—is their capacity for taking dissolved substances out of solution and retaining them often with very great tenacity. This phenomenon, which is of the greatest importance in nature and in many industries, is now generally called "Adsorption," and has become the subject of most extensive and careful investigation. Instances will occur at once to our readers. Specially striking is the power of "selective adsorption" (the term explains itself) possessed by many substances and organisms. Thus we should probably be quite ignorant of the existence of one important element, iodine, and should certainly not be able to use it freely, if it were not for the selective adsorption exerted by a number of seaweeds, as iodine cannot be shown to be present in sea-water by any of the usual tests.

Before entering upon the closer study of colloidal solutions, it may be well to answer two questions, which will naturally suggest themselves to the reader who has had no practical experience of the subject: how is it possible to tell whether a given solution contains colloids? and how can a few typical inorganic sols (the organic ones are more or less well known) be conveniently prepared?

As regards the first question, the most direct method—apart from ultra-microscopic examination, which requires expensive apparatus and considerable expertness, and will be dealt with later—of differentiating between true and colloidal solutions is still dialysis. This may be carried out in a number of different appliances. Graham's original dialyser, which is shown in text-books and price-lists with that persistence with which certain illustrations reappear long after they have become obsolete, has the drawbacks of small surface and of being difficult to get tight. It can, however, be easily improvised, as it consists simply of a shallow open cylinder, over one end of which the parchment paper membrane is tied. The solution to be examined is then filled into this cylinder, which is placed in a larger vessel, filled to the same level with the pure solvent, generally, of course, distilled water.

A very large surface is obtained, and the tying of the membrane is avoided by the use of parchment tube—sometimes inelegantly called "sausage skin" dialysers. These can be obtained in various diameters and are inexpensive, but frequently defective. It is therefore advisable, before proceeding to actual work, to select a piece free from defects by hanging up a length in U-shape and filling with distilled water. If no leak shows itself the piece may then be emptied, hung up again in the shape of a U (Fig. 1) in a tall cylinder and filled with the solution under examination. The cylinder is then filled with the solvent, or, preferably, a constant slow circulation is established by running the solvent in continuously and syphoning it off from the bottom.

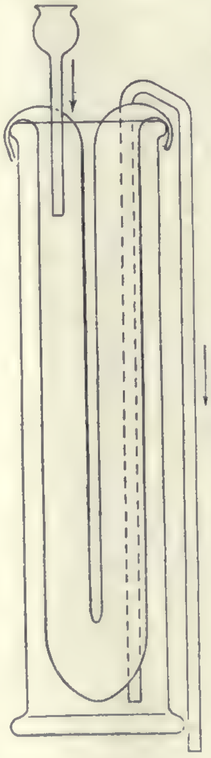


FIG. 1.

For examining small quantities only, by far the most convenient method is the use of the diffusion shells made by Schleicher & Schüll. These are seamless thimbles of stout parchment paper, which can be obtained in several sizes.

(*To be continued.*)

CURRENT LEGAL TOPICS.

THE FOOD AND DRUGS ACTS
AND
A COURT OF REFERENCE.

By W. JAGO, F.I.C.

THERE are many actions-at-law in which chemical problems come up incidentally for consideration; there are other cases in which they are the very essence of the matter in dispute. Especially does this apply to proceedings under the Sale of Food and Drugs Acts. There the main, if not the whole, question at issue is purely chemical in its nature; and yet the tribunal sitting in judgment need not have, and generally has not, any chemical training or knowledge. Of necessity, this leads to decisions of an unsatisfactory nature, and which are not infrequently at variance with the obvious and generally admitted deductions from chemical analysis. Another consequence is that on practically the same set of facts, diametrically opposite decisions may be given. This is well exemplified in the two following cases of alleged adulteration of ginger-wine and lime-juice cordial respectively with salicylic acid.

In the ginger-wine case it was proved that the wine contained 7.2 grains of salicylic acid per pint. Evidence was given that salicylic acid was a dangerous drug, and, for the defence, that in the quantity added it was perfectly harmless. The defendant was convicted. In the case of the lime-juice cordial, 8 grains of salicylic acid per pint had been added. Here the magistrate decided that the onus of proof of injurious effects of salicylic acid lay on the prosecutors, and in this they had failed. He therefore dismissed the case.

For our present purpose it matters little, if any, which decision was right, but obviously in one case there must have been a miscarriage of justice. There is the further difficulty that no guidance whatever is afforded either to the manufacturer as to what he may use, or to the public analyst as to what the law will support him in condemning.

In order, if possible, to avoid this *impasse* many of those who have to be responsible for setting this particular branch of the law in motion have urged the formation of some more competent tribunal, to which the name of a "Court of Reference" has frequently been applied. Thus, the Departmental Committee of the Local Government Board, appointed in 1899 to report on the use of preservatives and colouring matters in food, presented a report in 1901, in which, among other recommendations, was the following:—"(*g*) That means be provided either by the establishment of a separate Court of Reference or by the imposition of more direct obligation on the Local Government Board to exercise supervision over the use of preservatives and colouring matters in foods, and to prepare schedules of such as may be considered inimical to the public health." This raises the question as to what is understood by a Court of Reference, and at once the constitution of other courts exercising somewhat similar functions enters one's mind. When the Probate, Divorce and Admiralty Division of the High Court is sitting in Admiralty cases, that fact is symbolised not only by the display of the silver oar in court, but also in most instances by the appearance of two nautical-looking gentlemen, one on either side of the judge. These are the nautical assessors, and are usually chosen from among the "Elder Brethren of the Trinity." Their functions are to inform and advise the judge on purely technical nautical matters, when required. But the judgment is that of the judge alone, who is not bound to follow the opinion of the assessors.

Another interesting court of somewhat analogous character, though comparatively little known, is that of the Comptroller-General of the Patent Office. It is a part of the duties of that official to hear and decide matters arising out of opposition to the grant of an application for a patent. The opponent may probably say that a similar patent has been previously granted, and this allegation becomes the matter in issue. If the patent be a chemical one, the Comptroller-General has in effect to decide whether two patent specifications do in fact disclose the same or two separate chemical processes. In practice the Comptroller-General is usually a barrister, and among his staff of examiners has practically every branch of applied science adequately represented. If the matter in dispute be the application for a patent for a new dye, he sits with an examiner who has had a chemical training, and, if possible, in dyes, as an assessor. In this way his judgment is guided and assisted by expert advice of the necessary character.

How would the foregoing considerations guide in the formation of a Court of Reference for the purposes now being discussed? As the functions of such a court are judicial, presumably the presiding officer would be a member of the Bar, and the court itself would be endowed with such dignity and status as desirable for giving it the authority required. The other members of such court should consist of chemists, members of the medical profession (especially such as have qualifications in preventive medicine), and chemical manufacturers. For simple cases the presiding officer would sit with a selection of assistants; while for the more important decisions the whole panel might be called into requisition.

The extent of jurisdiction of such a court would be more or less determined by the amount of work thrown on it. Most likely, cases under the Foods and Drugs Acts would continue to be heard in the first instance by the justices, from whom a right of appeal to the Court of Reference would exist, to be exercised by either the prosecutor or defendant. Further, in cases of difficulty, and where the justices felt that the matter was one which ought to be decided by this court, they should, under proper safeguards, be empowered to transmit such cases for hearing and judgment to the Court of Reference. Another most important function of such a court would be to hear and decide applications for permission to employ new processes in the manufacture or treatment of food. Thus, on the discovery of a new preservative, the case for its use, and the objections thereto, should be heard and decided. Finally, such a court should be constituted one of Record, the recorded judgments of which should be regarded as binding, and therefore a guide to the courts of first instance.

Such is a brief sketch of the possibilities and uses of a Court of Reference, described as fully as possible within the limits of space of this article.

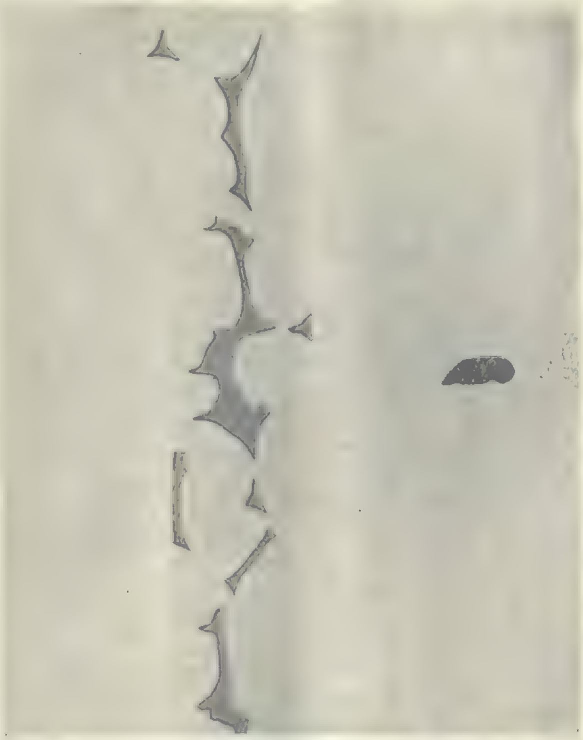
CHEMICAL ENGINEERING.

Coating Metal Surfaces.

THE question of a perfect join between dissimilar metals, such as copper and steel, or steel and aluminium, is one of extreme importance. When this can successfully be accomplished on a commercial scale it will be much used in the chemical industries. The mere coating of a metal by electrolytic methods is always of doubtful utility, for the slightest defect in the coating may destroy its value.

From the practical point of view a process which will satisfactorily deal with this important problem is to be desired. An invention by W. S. Simpson seems to have overcome some of the difficulties connected with this operation, and in view of the announcement made a few months ago in the *Times*, that a composite armour-plate manufactured by this method had been under extended trials, the following information of the process in question will be of some interest.

Briefly, the action involved depends upon the presence of carbon monoxide and the absence of oxygen at the touching surfaces. It is interesting to note that for the purpose of the actual joining of two metal plates it is not necessary that their surfaces be actually cleaned. The invention, in effect, consists in surrounding the metals at the time of the fusion of the lower melting one with a prepared carbon, such as a finely ground coke which has been made into a paste with a solution of sugar. At the high temperature, and before the copper fuses, the sugar has already carbonised and effectively holds the coke particles in position, thus forming a natural mould. At the correct temperature the copper melts and any metallic oxides are reduced, and the two surfaces unite. More than this, actual diffusion of the copper or aluminium into the iron or steel takes place. As alloy of copper and iron is formed in the first case and the joint is so perfect in its nature that after the copper has cemented the two surfaces of iron, fracture will not take place within the copper area, but will run through the iron itself. This may be explained by the fact, as Prof. Arnold has shown, that mild steel, when alloyed with 1·8 per cent. of copper, increases in tenacity from 22 to 35 tons per square inch, with an elongation of 31 per cent. Micrographic analysis at once indicates that the original joining layer of copper between the two steel surfaces is replaced by a solid solution or molecular mixture at the edges of the weld. It will be seen in the accompanying micro-photograph (magnified 500 linear), due to Prof. Arnold, that in places a solid solution of copper in iron has actually replaced the copper join, which is broken up in the remarkable way indicated in the process of ultimate diffusion.



COPPER WELD BETWEEN TWO STEEL PLATES (× 500).

The solid solution of copper in iron is microphotographically almost indistinguishable from the steel itself, so that only the copper is seen. If the fusion is prolonged no visible weld line is left, but merely a solution of copper in the steel molecularly continuous, and considerably stronger than the metal itself. The weld in the ordinarily accepted term no longer exists. The dark areas seen in the steel itself are probably sulphide of manganese or slag.

This process is seemingly available for joining any metal in decorative effect or otherwise. Thus lead may be directly joined to steel.

The results obtained are evidence of the direct influence of chemical research on mechanical engineering. It is thought that a composite plate may be prepared by joining sheets of different steels together by this process, which will, on the one hand, give reduced weight, and on the other be increasingly shell proof.

W. P. D.

THE "DIONIC" WATER TESTER.

By J. G. DAVIS, B.Sc., A.C.G.I.

THE researches of Kohlrausch proved the electrical conductivity of pure water, containing in solution an electrolytic substance, to be due almost entirely to the presence of that substance, and, further, to be proportional to the concentration for very dilute solutions. In other words the conductivity was shown, within limits, to be proportional to the number of ions, or to the quantity of the dissolved matter occasioning it.

These principles have found practical application of considerable importance industrially in the invention of Messrs. Digby & Biggs. The apparatus, as manufactured by Messrs. Evershed & Vignoles, Ltd., consists of a glass U-tube, to contain the water under test, fitted at the upper extremities with platinum electrodes of hollow cylindrical form. The latter are connected by a plug, carrying twin flexible leads, to the terminals of a separate sealed compartment (indicated on the right in figure), in which it is found convenient to place the remainder of the conductivity meter of which the tube forms a part, with its exciter. The latter is a small hand-driven dynamo, fitted with a constant speed clutch, and is identical with the type used in the "megger" for insulation tests, supplying continuous current at a constant pressure of, say, 100 volts to the terminals of the meter. The coils in the sealed compartments are arranged so as to adjust themselves automatically to the electrical conditions, and to register directly the conductivity of the electrolytic solution in the U-tube by means of an index moving over an engraved scale. Provision is made for filling the tube, and for the escape upwards of air and liberated gases, and also for the draining and cleansing of the apparatus between tests. Since only rubber, glass, and platinum are in contact with the liquid, contamination of it or corrosion of the parts is entirely averted.

The ratio of cross section to effective length of the liquid column between electrodes was in the original type of "Dionic" Tester 1 : 10, this instrument measuring in the few seconds necessary to establish the maximum polarization of the electrodes with a current not exceeding 0·004 ampère.

In calibrating the scale allowance has been made for the back E.M.F. set up across the electrodes, and the unit employed represents the reciprocal of one megohm.

In the original form the scale extends from zero to 2,000 units, and with it impurities may be traced and directly measured in quantities so small as to entirely escape chemical analysis.

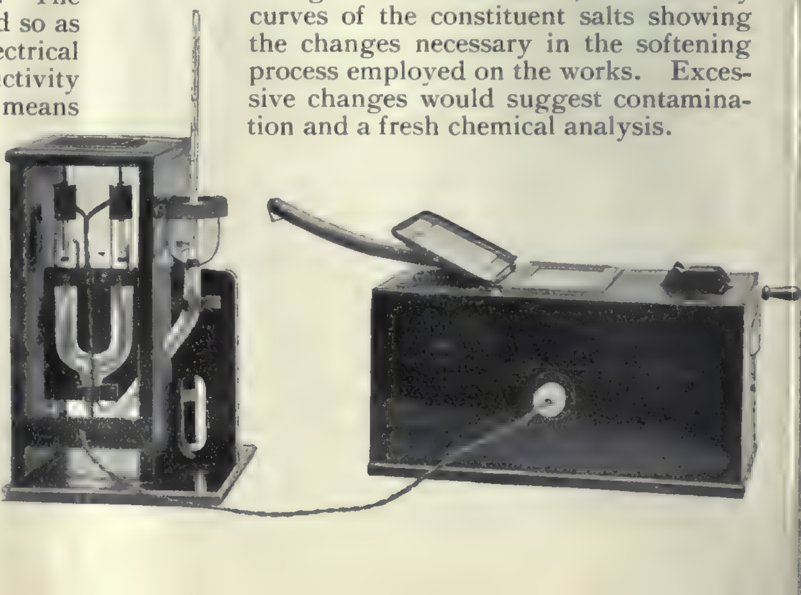
Testers of lower sensibility, having greater length of tube combined with decreased cross section, have proved useful in dealing with solutions of greater strength. They have been used particularly in the measurement, without dilution, of the salts in sea-water used for boiler feeds, for which purpose the ordinary sailnometer is proved useless, apparently owing to the indeterminate temperature error.

A *temperature correction* of known average amount is made of necessity with the "Dionic" tester, and takes the form of a factor, by which the reading M of the meter (taken at the prevailing temperature T°C. of the test, as registered by the thermometer shown in figure) is multiplied. For convenience, a table giving the value of this correction factor for any temperature between 10°C. and 40°C. is supplied. For the original highly sensitive meter

$$\underset{\text{(at 20°C.)}}{\text{Corrected conductivity}} = M \times \frac{100}{56 + 2{\cdot}2\,T}$$

The industrial uses of such an apparatus are many and varied: applications to the measurement of the hardness in water, leakage of cooling water into surface condensers, the priming of steam-boilers, and impurities present in minute traces in distilled water being among the foremost. Dealing very briefly with these, it may be mentioned that, where pollution by sewage is absent, the conductivity measures the hardness as effectively as the more laborious "Soap test."

A chemical analysis having been made primarily in conjunction with the electrical test, subsequent periodic conductance tests will indicate changes in the hardness, conductivity curves of the constituent salts showing the changes necessary in the softening process employed on the works. Excessive changes would suggest contamination and a fresh chemical analysis.



The conductivity at 20°C. of the solution being denoted by K, the solvent being in all cases pure distilled water, and the parts by weight (reckoned per million of the solvent) of the added matter being P, the following approximate laws are found to hold :—

			Up to a concentration of
(i.)	For pure sodium chloride	$P = 0{\cdot}564\,K$	... ($0{\cdot}2\%$).
(ii.)	For calcium carbonate (chalk)	$P = 0{\cdot}416\,K$	... ($0{\cdot}04\%$).
(iii.)	For London tap-water	$P = 0{\cdot}000019\,K$	... (10%).
	,, ,, ,, mean value.	$P = 0{\cdot}000025\,K$	... (100%).
(iv.)	For sea water	$P = 0{\cdot}0000001{\cdot}6\,K$	(3%).

The widely differing *slopes* of the conductivity curves, as shown by the above mean-values, illustrate the ease of discrimination and the possible accuracy of the tests. The departure from the above approximate linear laws becomes marked in cases (iii.) and (iv.), and increasingly so with higher concentrations, the curves becoming markedly convex to the axis of K. The "Dionic" method of determining the rate of condenser leakage has proved effective on extensive tests.

As a rapid and accurate test for the purity of distilled water the conductance method may be used. As regards the pollution of rivers, or increased impurity of sewage effluents, as indicated by increased conductivity, there is evidence from the records at Paris and elsewhere that the test may prove valuable. It is to be noted that low conductivity is no criterion of bacteriological purity. The results of a test must be supplemented by an accurate knowledge of the sources of supply to establish with any certainty that a water is suitable for domestic supply purposes.

Apart from such considerations, however, for purposes where the strength of solutions of any kind is to be determined, the apparatus undoubtedly combines accuracy with rapidity and simplicity of manipulation.

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER I.

HISTORICAL REVIEW AND NATURE OF RESEARCH.

> "The chymists are a strange class of mortals impelled by an almost insane impulse to seek their pleasure among smoke and vapour, soot and flame, poisons and poverty, yet among all these evils I seem to live so sweetly, that may I die if I would change places with the Persian King."
> (*Physica Subterraneæ.*)

OUR knowledge of natural phenomena, and therefore of chemistry, and the experimental sciences which have sprung from it in the course of its development, is confined within the range of our senses. In certain cases this natural limit has seemingly been extended by the aid of such instruments of precision as the spectroscope or microscope. The application of mathematics, when applied to the extension of our knowledge in this direction, may also be said to have served a similar purpose.

The results recorded from a study of the conditions which control, represent, or indicate in accepted terms, such changes or phenomena as have been observed, have been brought to a state of order, and expressed in terms of so-called laws. In this way certain phenomena have been symbolised in terms of definite comparison. A classification of the results obtained has proved of first importance to the investigator in the further extension and study of his science. In this way the work of the past is under continual revision and criticism.

It may not be possible to determine how far the conclusions arrived at represent the ultimate conditions of energy and space; or whether these can be expressed in terms of our system of thought. Facts and phenomena may be so distorted in such expression, or so partial in their nature, that the conclusions arrived at may only represent actual fact as a shadow on the wall represents the substance.

There is, however, a growing sense of security in the value of the methods employed, and a belief that they certainly indicate the nature of actual conditions, even if they do not represent them in absolute terms. This conviction is based upon the nature of the evidence brought forward by the practical investigator.

Speculations as to ultimate conditions must have no adverse influence on the value of the experimental method in the student's mind. Rather should the contrary effect be produced. The programme before the chemist is sufficiently definite. Investigations must be continued from the position it occupies to-day, extended in every possible direction by the direct aid of experiment, and carried to the utmost limit.

Knowledge obtained by the aid of experiment is said to have been obtained by a process of induction. This may, within certain limits, be utilised to a further extent by the process of deduction. This attempt to extend knowledge on lines of certain theoretical conclusions, by suggesting the nature of results which may reasonably be expected to follow under conditions somewhat equivalent to those already dealt with, has a definite value.

Thus the future may to an extent be anticipated, and results inferred or foretold by such utilisation of direct knowledge. By this means important conclusions have been arrived at. The existence of unknown elements and their properties have been deduced and subsequently verified by experimental evidence.

In this and other directions such deductions have been fully justified as a means towards progress. Conclusions based upon theory have been of great value as stepping stones to a further advance, and the bridging (in a temporary way) of gaps in the chain of experimental evidence.

At the same time a sharp line must be drawn between knowledge obtained by these direct and indirect methods, which might be defined as of the first and second order respectively. When an investigation is partly based on theoretical speculations, the results arrived at must be of a convincing nature, if they are to be generally accepted. They must be continually subjected to examination in the light of further experimental knowledge, being compared with any new facts which may support or oppose those originally set out.

In the absence of any definite plan of action a preliminary scaffolding based on theory must sometimes be erected in advance. When the experimental results obtained do not conform to or uphold this, it must be correspondingly modified, or even replaced, by one which agrees with the further facts disclosed by the investigation.

Such use of theory is perfectly legitimate. It serves a purpose in indicating new lines of research, which the results obtained by the investigator must either confirm or destroy.

The relative value of induction and deduction has been much discussed. The successful investigator must be prepared to make every use of both methods, verifying all deductions by direct experiment (when this is possible) as the research opens out and progresses towards its logical conclusion.

Chemical research is generally confined to the study of changes which matter undergoes under definite conditions of strain, with an examination of the products obtained and the conditions ruling at the time; this is completed by the setting out of the results obtained in terms which express such actions.

A record of such facts has been defined as crude knowledge, which in turn has been said to be the raw material of science.

Knowledge is regarded as generalised or empirical. In the latter case it has not yet been expressed in terms which can be recognised, or referred to any known cause or law. Facts of this nature are considered useless for the purpose of science, although they may have a definite value in the arts and manufactures. Where these exist there is a further call for an investigation of unrecognised conditions. Many investigators pay special attention to these reactions, for they naturally indicate suitable subject matter for further research. In the industrial world such phenomena are constantly met with, but are in many cases lightly passed over. Thus promising material for research is too often neglected for want of a suitable opportunity for investigation. As this is met with in the works rather than in the laboratory, this undesirable condition is still prevalent in many directions. Under the stress of circumstances the connecting link between the passing observation and the means to examine it in detail is often absent.

Sufficient attention is not paid to this important source of subject matter. Those who have followed up investigation on such lines, recognise its special value as an aid to industrial advancement and as a suitable training for the student.

HISTORICAL REVIEW OF PAST INVESTIGATION.—Chemistry as an exact science dates back to the middle of the seventeenth century, although it has been practised for thousands of years in a purely empirical manner.

It may possibly have originated with the manufacture of alcohol by a process of fermentation, and the natural control of such operations ("History of Chemistry," Thorpe, 1909), which is said to have been manufactured in China in the year 2220 B.C. Dyeing, the production of leather, the working of metals and alloys are also of great antiquity. There is direct evidence that these operations were conducted with skill by the Egyptians from very early times.

The speculations of Jean Rey, in France, and of Descartes, foreshadowed the birth of systematic investigation on experimental lines.

In this country research may be said to date from the formation of the Royal Society, and the immediate results which led up to this important event. In 1661 Robert Boyle published the "Sceptical Chemist." In this he outlined a new philosophy. This investigator, with the help of certain supporters, sought to cultivate the system which was at the base of his suggestion. The Invisible College, based on a conviction "that they were satisfied that there was no certain way of arriving at any knowledge, unless they made a series of experiments upon natural bodies," was founded. Boyle's personal work set a high standard for such investigation. A consideration of his discoveries, experiments and conclusions, is of extraordinary interest to the student. His conception of an element is that in general use to-day; but his great service to science and learning generally consisted in the new spirit he infused into chemistry, which at once lifted it into the plane of a great science. It no longer remained the handmaid of medicine, as practised in those days.

As a result of this advance in thought, chemical research was seen to offer great possibilities. The Invisible College became the Royal Society, the charter of which was obtained in 1662.

Robert Boyle's conclusions were destined to influence the entire scientific world, and to give rise to modern chemistry. To the close ring of mere thinkers the experimental basis of science was definitely proclaimed.

An examination of Boyle's work brings with it a certain realisation of a power of concentration and determination which are factors in all original work.

Its lasting influence emphasises to a degree the importance of knowledge based on direct experiment, and indicates the respect which such work must always command. It shone out as a bright star in a firmament of make-believe. It still remains an example to those who have the advantage of working under modern conditions. Boyle's method has spread through all research and has become the recognised basis of all scientific knowledge.

Lemery followed in Boyle's footseteps, also insisting that chemistry was a science of observation. He suggested the natural division of chemistry into organic and inorganic branches. Boerhaave published his "Elementa Chemia" in 1732. This work greatly influenced the thought of the period. The investigations of Priestley and Cavendish, which followed, are too well known to demand more than passing mention. With those of Lavoisier, Dalton, Berzelious, Prout, and Davy, they bring us to the early days of the nineteenth century, when Nicholson and Carlisle first decomposed water by the aid of the voltaic pile. This observation received great attention, deepening the rising interest in this progressive science, and materially assisted in its general development.

Thus a rapid advance in chemistry followed the recognition of the unique value of direct investigation by experiment. Boyle's suggestion and its definite acceptance as the only source of knowledge of natural phenomena has led up to the present position of modern chemistry and the experimental sciences.

By an examination of the sequence of developments, which followed as a direct result of the general acceptance of this idea, the student may realise the supreme power and value of research, and measure its direct influence on the progress of civilisation. This suggestion of continual progress must be the underlying thought. It must guide the investigator in all his ways. It must find expression in any work which is to have a permanent value. Thus, progress by research has become the hall-mark of science, and is rapidly occupying an equally definite position in the industrial world.

The historical side of this development may be followed in a recently published work, "The History of Chemistry," by Sir Edward Thorpe (1909). This, with its excellent bibliography, may form a suitable introduction to the subject. For further details the other standard works on this subject may be consulted. The student should also be acquainted with the Alembic Club Reprints and Ostwald's "Klassiker."

(*To be continued.*)

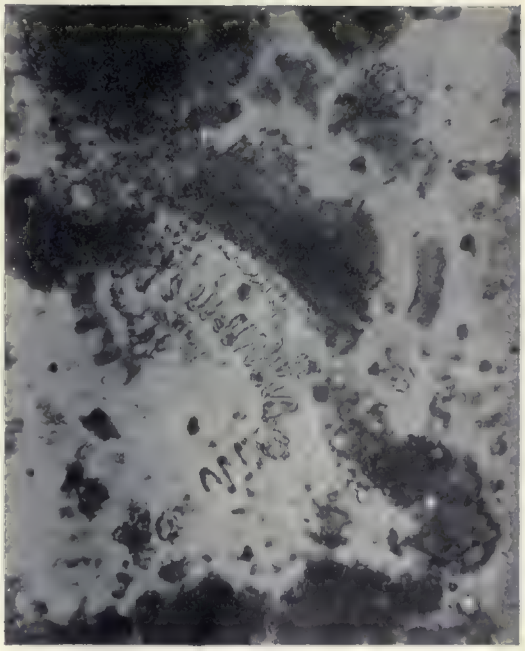
REVIEWS OF BOOKS.

COCOA and CHOCOLATE, Their Chemistry and Manufacture. By R. Whymper. J. & A. Churchill, London, 1912. P. 316 + xi.; Chapters XXVI., 12 Plates, 19 Figures and Frontispiece. 15s. net.

This exhaustive work is divided into three parts, dealing respectively with History, Botany, and Agriculture of Cocoa, Manufacture of Chocolates and Cocoa Powders, and Chemistry of Cocoa.

Since the days of Cortes (1528) these products have steadily grown in favour in Europe, until, in 1908, 56,566,515 lbs. (raw and manufactured) are said to be consumed in the United Kingdom. The cultivated tree, *Theobroma cacao*, grows to an average height of 25 ft. After dealing with the selection of site, soil, manure and seed, the author passes into the consideration of planting, diseases, pruning and picking.

The real interest of the chemist then comes in with the fermentation of the beans. The exact condition to which the beans must be brought by fermentation is known only to the practical planter, whether the process is conducted in vats or in sacks in the sun. The temperature of 60°C. must never be exceeded. A yeast fungus, *Saccharomyces-theobrome Preyer*, is seemingly the chief cause of the action, although later on *Mycolderma aceti* may ultimately set up acetic acid fermentation.



Pure Cocoa.

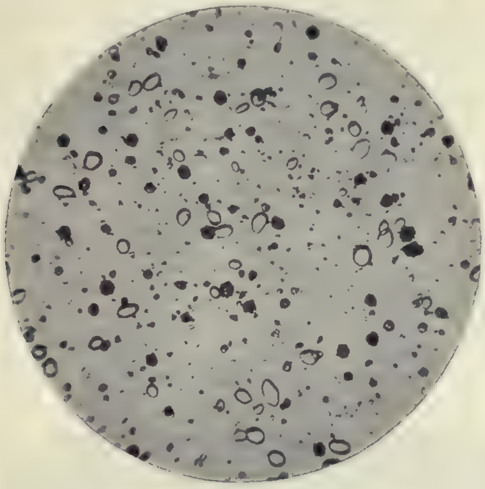
This fermenting action produces, if properly conducted, the required colour and aroma, and the operations of washing, drying, and polishing may complete the operations.

The characteristics of the cocoa beans, as produced in Brazil, San Thome, Ecuador, Trinidad, etc. (amounting to an estimated world's production of 174,000 tons in 1909), are then dealt with.

The organic constituents of cacao beans are divided into seven headings, and the inorganic constituents are also discussed.

Cleaning, sorting, and roasting are then considered in detail, and a clear and concise account of the machinery used is supplemented by photographs of actual machinery used in the rubbing, husking, and winnowing and milling processes, and for the expression of fat by hydraulic power.

The term "soluble" cocoa is then described, which really is a misnomer. In reality the cocoa powder is mixed with a carrier, such as starch, which in effect prevents the cocoa powder from falling to the bottom of the cup.



Cocoa adulterated with Starch.

The modern method of treatment with alkali, to give so-called solubility, is claimed to be a distinct advantage. Details of cost of plant are then described for such treatment.

The author then passes on to the analysis of cocoa powders, etc., giving many tables of analysis by leading authorities, and then to the manufacture of chocolate and the mixing and refining processes used in the same. Here again the text is illustrated by photographs of modern machinery, the analysis of plain chocolate and receipts for making them. This is followed by similar particulars of milk chocolates and milk chocolate powders, and particulars of the methods used to obtain aroma and flavour. The last section of the book is devoted to the chemistry of cocoa, and deals in great detail with the methods in vogue for estimating the husk, fat, moisture, fibre, ash, theobromine (0·4—2·0 per cent. of the raw or roasted husk), proteid matter, starch, etc., with reference to Fischer's successful attempt to synthesise theobromine from a lead salt of zantheine ($C_5H_2Pb_6H_4O_2$).

The examination of cocoa nibs then follows on similar lines, and then that of cocoa powders and chocolates. An interesting chapter deals especially with the microscopical examination of cocoa products, the appearance of pure cocoa and a cocoa adulterated with arrowroot starch being shown in the accompanying photo-micrographs. The methods of analysis are summarised in the last chapter, and an appendix gives provisional definitions and standards of cocoa, bibliography, and a very full index facilitates reference to the subject matter.

Right through evidence is everywhere seen of the care taken in the compilation of this important work, which must clearly remain a standard on these increasingly valuable products. The full-page illustrations are remarkably clear and serve their purpose, while the book is full of important information of the products in varying stages of manufacture.

THEORETICAL CHEMISTRY. W. Nernst. Macmillan & Co., London, 1911. Revised from the 6th German Edition by H. T. Tizard, in 4 Sections and 32 Chapters. P. 803 + xxi., including Author and Subject Index.

This text-book has met with such success that another edition has been called for, making the third since the work was first translated in 1895.

The scope of the work is well known, and this last edition contains an account of the author's new theorem in thermodynamics, a chapter on radioactivity and a large amount of new matter.

Following an introduction, the universal properties of matter, so far as they are known, are set out in terms of aggregation, physical mixture, and solution. Section II. is taken up with a consideration of the atom and molecule, entering into such subjects as the constitution of the molecule, molecular structure, dissociation, the physical properties of salt solutions, metallic state, radioactivity, collodial state, and a very interesting summary on past speculation and research into the absolute size of the molecule.

Section III. deals with the so-called transformation of matter, and considers the laws of mass action, homogeneous, and heterogeneous systems, chemical equilibrium in salt solutions, and chemical kinetics.

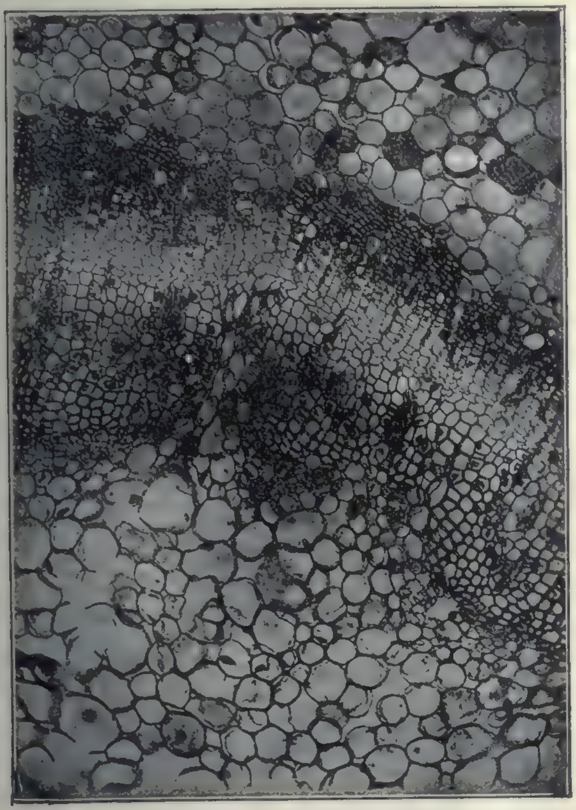
Section IV. discusses the transformation of energy, and is devoted to a detailed account of thermo-chemical, electro-chemical and photo-chemical reactions, and the laws which have been deduced concerning them.

The whole argument of the book is characteristic, very thorough, and clearly set out. The success which has met the production of past editions will be reflected in this one. A word may be said concerning the translation, which is of such a nature that there is little internal evidence of a change from one language to another. The index of authors indicates how comprehensively the book deals with the subject under consideration.

WOOD PULP AND ITS USES.

CROSS, BEVAN AND SINDALL, Westminster Series. CONSTABLE & CO.. London, 1911. P. 263 + vi., Chapters XI., Index, and 25 Illustrations.

The book before us is written for the general reader rather than for the specialist. It describes in some detail wood pulp as the raw material of the paper manufacturer, giving examples of the structure of various woods and their physical properties. Passing on to a consideration of cellulose itself, particulars are given of it in its structureless form (artificial silk, etc.), and its reactions discussed in a general manner. Also those of the lignocelluloses and their photo-chemical reactions.



TRANSVERSE SECTION OF *Pinus sylvestris*.

The source of supply is then considered. It is interesting to note, in view of recent activity, that Canada has 800 millions of acres of forest, against America's 400, and Russia's 500. Great Britain has 3 million, with a total available area for afforestation of 9 million acres. A comparison between the manufacture of mechanical wood pulp and chemical wood pulp is then undertaken, and the process of bleaching is followed in some detail.

The actual production of paper is then discussed, with the utilisation of wood waste. The growing importance of the influence of wood pulp in the industries is then considered, and an account of paper-pulp yarn and its production is given.

Sufficient has been said to show that this work thoroughly fills its allotted space in this series of popular text-books, and gives a satisfactory account of recent progress in this important industry.

PRINCIPLES OF BLEACHING AND FINISHING OF COTTON.

By Trotman and Thorp. GRIFFIN & CO., 1911. 341 pages + vi. and Index. 16s. net.

This important work deals in detail with the practical as well as the theoretical side of the subject. After reviewing the structure and constituents of raw cotton, the important question of cotton-testing is considered in full detail in both the yarn and piece state. A chapter then deals with the carbohydrates, including cellulose, the sugars, and starches. The gelatinisation of starch is considered, and very useful information concerning hydrocellulose and oxycellulose is given.

The question of water supply is then gone into, and the different methods of softening discussed, this section being illustrated with diagrams of the actual plant.

Then follows chapters dealing with the possible action of bacteria, the preparation of piece cotton goods, and their treatment during the preliminary and actual processes of bleaching, including full details of the machinery in actual use under modern conditions, no less than 24 pages being devoted to Kiers alone. The very important consideration of washing machines is equally well dealt with; also the question of chemical materials used in the different processes of bleaching, including the different types of electrolytic apparatus used in their preparation; and the bleaching of coloured goods, and the all-important recognition of the various stains brings this section of the book to a close.

The consideration of the materials and processes used in finishing the fabrics, a chapter on auxiliary machines and processes, and one on calendering brings this important work to its natural conclusion.

There is little to find fault with and much to praise in the method of treatment adopted by the authors. This work should be of real use to both the practical worker and the student. The illustrations are satisfactory, and right through the book there is evidence of that practical acquaintanceship with actual processes which is so essential to a writer of such a text-book.

W. P. D.

ALLEN'S COMMERCIAL ORGANIC ANALYSIS. Vol. V.

Tannins, Dyes, Colouring Matters, and Inks. Edited by W. A. DAVIS, B.Sc., and S. S. SADTLER, S.B. Contributors: W. P. Dreaper, F.I.C., J. F. Hewitt, M.A., D.Sc., W. M. Gardner, M.Sc., A. F. Seeker, B.S., P. H. Walker, M.S., E. Feilmann, B.Sc., Ph.D. J. & A. CHURCHILL. Med. 8vo, 704 + ix. pages. 21s. net.

The book under review is a new edition of Vol. V. of that well known standard work, "Allen's Commercial Analysis," which has for many years been the reference book of the public analyst and consulting chemist.

The plan adopted in the recently issued new volume of this monumental work, of making well known authorities responsible for the various chapters dealing with the subjects in which they are acknowledged experts, is one to be commended. In the volume under review the subject matter has been divided up under eight headings: "Tannins," by W. P. Dreaper; "Analysis of Leather," by W. P. Dreaper; "Dyes and Colouring Matters," by W. P. Dreaper and E. Feilmann; "Dye-stuffs," by J. T. Hewitt; "Colouring Matters of Natural Origin," by W. M. Gardner; "Analysis of Colouring Matters," by W. P. Dreaper and E. Feilmann; "Colouring Matters in Foodstuffs," by Albert F. Seeker; and "Inks," by Percy H. Walker.

There is a tendency for certain portions of the book to overlap, which might have been avoided by a more careful editing; for example, the chapter on Colouring Matters in Foods might with distinct advantage have been incorporated with the chapters on Dyes and Colouring Matters, with which it is so intimately connected.

It is pleasing to find the section on the Analysis of Coal-tar Colouring Matters so well done. The more recently published works on the detection and identification of dyes on various fibres have been included; also various tables for the qualitative recognition of commercial dye-stuffs, thus providing a handy reference to the whole of the available reliable literature on this important subject.

The chapters on the Coal Tar Colouring Matters, as well as that on the Colouring Matters of Natural Origin are evidently written from the standpoint of the textile dyer, and in consequence they lack somewhat in details as to the applicability of the various stuffs in other industries, which information would have been of great value to the public analyst. The addition of a few pages dealing with the methods in common use in dye-house laboratories, for the making of standard dye trials and the practical valuation of commercial dyes, would also have been useful.

It is somewhat disappointing to find the particulars given for the valuation of the natural dye-stuffs to be so meagre, and an absence of details as to the quantitative examination of the more common adulterants found in commercial dyewood extracts.

In the section on the Tannins, the author has omitted any mention of the recently published work by Stiasny on the detection of adulteration of various extracts with other tannins; the methods given for the detection of adulterants in sumach are also out of date. The work of Lamb, Harrison, and Priestley on the microscopical examination of sumach adulterants is entirely ignored; also the publications of Trotman and Lamb on the analysis of the mineral constituents of sumach and its adulterants.

The book is one which is unquestionably a very valuable addition to our library, and though primarily intended as a work of reference for chemical analysts, it is likely to be equally valuable as a text-book for the student specialising in dyeing or tanning.

M. C. L.

Sugar Cane Crushing Mill.

The largest mill yet constructed for the crushing of sugar cane has been completed by Messrs. John McNeill & Co., of Govan, to the order of a German firm for the Argentine. It can deal with 1,500 tons of cane per day.

Exhibition of Non-Ferrous Metals.

This exhibition is announced from May 6th to the 18th, 1912, at the Agricultural Hall, London. Sir G. A. Muntz, Bart., President of the Institute of Metals, is the President. There is a very strong list of Vice-Presidents, and Mr. F. W. Bridges, who so successfully acted as organising manager to the Chemical Engineering Exhibition of last year, occupies a similar position to this exhibition. He is assisted by a strong Hon. Advisory Council, which contains the names of many important chemists. A local committee has been formed for Birmingham, of which Mr. Boeddicker is chairman.

CORRESPONDENCE.

The Editor will publish letters dealing with subjects which may be of general interest.

Books Received.

"Practical Cotton Finishing," by J. Harold Edge, Trades' Papers Publishing Co., Ltd., 1911. Price 3/6.

"Theoretical Chemistry," by W. Nernst, from the 6th German Edition. Macmillan & Co., 1911. (Reviewed this number.)

"The Manufacture of Chemical Manures," by J. Fritsch. Scott, Greenwood & Son, 1911.

"Higher Mathematics for Chemical Students," by J. R. Partington. Methuen & Co., 1911. Price 5/-.

"Wood Pulp and Its Uses," by C. F. Cross, E. J. Bevan and R. W. Sindall. Constable & Co., 1911. Price 6/- (Reviewed this number.)

"The Principles of Bleaching and Finishing of Cotton," by S. R. Trotman and E. H. Thorp. C. Griffin & Co., 1911. Price 16/- net. (Reviewed this number.)

"Allen's Commercial Organic Analysis," edited by Davis and Sadtler. Vol. 5. Tannins, Dyes, Colouring Matters, Inks. J. & A. Churchill, 1911. Price 21/- net. (Reviewed this number.)

"Cocoa and Chocolate: Their Chemistry and Manufacture," by R. Whymper. J. & A. Churchill, 1912. Price 15s. net. (Reviewed this number.)

"Some Chemical Problems of To-day," by R. K. Duncan. Harper Bros., 1911. Price 7/6 net.

"Nitro-Cellulose Industry," Vols. I. and II., by Edward Worden. Constable & Co., Ltd. 1911. Price 44/-.

"The Chemistry of the Coal Tar Dyes," by Irving W. Fay. Constable & Co., Ltd. 1911. Price 16/-.

"Science Progress." John Murray. October, 1911. Price 5/- net.

"The Calorific Power of Gas," by J. H. Coste. Pages 310+vii., including Index and Appendix. 57 Illustrations. Griffin & Company, Ltd. Price 6/- net. 1911.

PHYSICAL CHEMISTRY.

NOTES ON TWO THERMO-REGULATORS.

By W. R. BOUSFIELD, M.A., K.C.

(Read before the Faraday Society, December 6, 1911.)

THE first Fig. represents a regulator specially designed for an air thermostat, in which a battery of standard cadmium cells was kept. The principle is equally available for a water thermostat, though slight changes of detail would be necessary.

The source of heat to be regulated was an electric radiator, worked direct from the power mains carrying an alternating current at 240 volts. *A B* are the upper and lower surfaces of a column of mercury contained in a barometer tube. Part of this mercury column is in series with the radiators and the current from the main, which passes into and out of the mercury by platinum wires, 1 mm. thick, sealed in the glass walls of the tube. The current enters through the wire *C*, which is placed sufficiently far below the surface *A* to be always immersed. The circuit is closed by contact between the lower platinum wire *D* and the lower surface *B* of the mercury. The barometer tube communicates with the bulb *E*, which is filled with hydrogen through a cock *F*. A cock C_π serves to regulate the quantity of mercury for the desired temperature, and enables the bulb *E* to be thoroughly washed out with hydrogen gas. Overheating of the thermostat expands the gas and causes the mercury surface *B* to be forced away from the platinum wire, thus cutting off the current. The reverse process takes place when the temperature falls below the mean.

The tube is furnished with two bulbs at *A* and *H*. The mean pressure in *E* must be so chosen that the mercury in *A* normally occupies about half the bulb *A*. The purpose of the bulb *H* is to supply sufficient mercury to fill the bulb *A* in case of overheating, without allowing the lower level of the mercury to be depressed to the bottom of the tube, which would permit air bubbles to pass and spoil the vacuum in *A*.

It is best to instal the regulator with the mean pressure in *E* about equal to mean atmospheric pressure. The length of the tube will then be that of an ordinary barometer. In this way the possible leakage of the mobile hydrogen through defective taps is prevented.

In such an apparatus, where the full current through the radiators from a pressure of 240 volts in the mains passes through the mercury and gives rise to a spark at *B* on breaking the contact, it was a matter of vital importance to prevent oxidation or other deterioration of the surface of the mercury. For instance, it was anticipated that nitrogen with traces of oxygen and water vapour might give rise to nitric acid and cause trouble. Hydrogen forms no compound with mercury, and was tried in the first instance. It proved completely successful. Last winter the regulator was kept working day and night for six months, maintaining a temperature of about 18° C. No tarnishing of the mercury surface has taken place, and it seems as bright as when it was first installed.

A point of importance is that the regulation is independent of variations of atmospheric pressure, owing to the gas being completely enclosed and working against a vacuum.

To find the sensitiveness, let—

P = pressure of hydrogen in mm. of mercury.
V = volume in c.c.
θ = absolute temperature.
A = sectional area of tube at *A* in cm.²
B = sectional area of tube at *B*.
x = distance of mercury surface at *B*, below platinum point in mm.
h = mean height of mercury level at *A* above platinum point in mm.

$$P = h + \left(\frac{B}{A} + 1\right)x$$

$$\delta P = \left(\frac{B}{A} + 1\right)\delta x$$

$$\delta V = B\delta x \times \frac{1}{10} \text{ (since } x \text{ is mm.)}$$

$$PV = C\theta$$

$$C\frac{d\theta}{dx} = P\frac{dV}{dx} + V\frac{dP}{dx}$$

$$= \frac{1}{10} BP + \left(\frac{B}{A} + 1\right) V$$

i.e.—

$$\frac{1}{\theta} \cdot \frac{d\theta}{dx} = \frac{B}{10V} + \frac{1}{P}\left(\frac{B}{A} + 1\right).$$

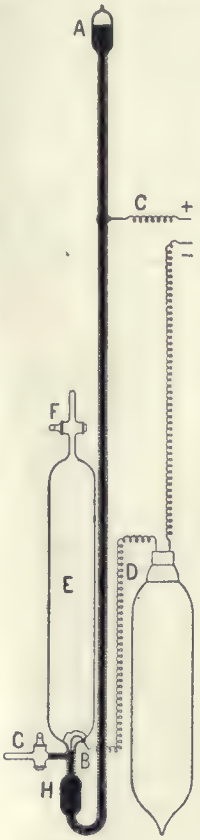


FIG. 1.

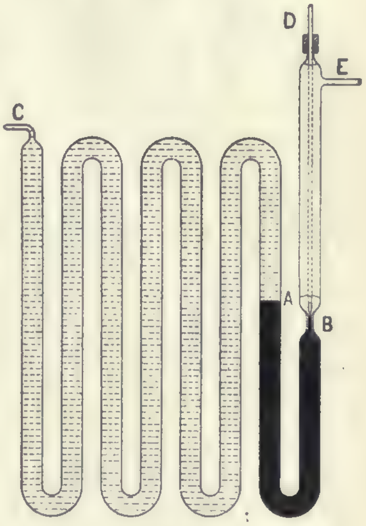


FIG. 2.

For greatest sensitiveness $\frac{d\theta}{dx}$ must be as small as possible. Hence V and A must be as large as possible. The sensitiveness is also increased by making P large, but for the reasons mentioned it is best kept at about atmospheric pressure.

If— $B = 0{\cdot}1$ cm.² $A =$ cm.²
$P = 760$ mm. $V = 760$ c.c.
$\theta = 300°$ equivalent to 27° C.

we have—

$$\frac{d\theta}{dx} = \frac{300}{760}(0{\cdot}01 + 1{\cdot}025)$$

$$\delta\theta = 0{\cdot}4\,\delta x.$$

With these dimensions 1 mm. fall of the mercury contact surface at B corresponds to 0·4° C., or 0·01° C. to one-fortieth of a mm.

The sensitiveness realised depends of course upon the activity of stirring of the contents of the thermostat. The comparative sensitiveness relative to that of a regulator depending on this expansion of mercury or toluene is chiefly influenced by the fact of the small heat capacity of the hydrogen contained in the bulb and the large surface available for rapid heat exchange.

Water Bath Regulators.—This is a modified form of Lowry gas regulator. It was designed in the form of a grid, so as to be placed near the side of a large water bath, in order to take up as little room as possible. The last U shaped limb contains mercury from *B to A*. The remainder, from *A* to *C*, is filled with toluene. Easy filling is secured by the use of a small tube *C*, which is sealed with a blow-pipe when the mercury and toluene are in place. It is not difficult to fuse the tube *C* when filled with toluene, as the heating causes the toluene to boil near *C* and fill the tube with vapour, which excludes air, so that when the tube cools it is filled with toluene right up to the end without an air bubble. D is the gas inlet pipe, which is closed by the expansion of the mercury. *E* is the gas outlet pipe. The tube *D* is kept in place by a rubber stopper, which permits of its ready removal. Regulation to any desired temperature is easy. The regulator is placed in the bath, which is kept at the desired temperature for a few minutes. The tube *D* is removed, and an excess of mercury poured in. When the temperature is as desired, the excess of mercury is sucked out with a filter pump through the tube *D*. Thus the right quantity of mercury is obtained corresponding to the required temperature. This form of regulator is affected by variations of gas and atmospheric pressure. It is not difficult to secure regulation of the thermostat within ±0·01° C.

Institute of Chemistry Lectures.

UNDER this new scheme Mr. Bertram Blount delivered his second lecture on Cement at King's College, on Friday, December 1st. Proceeding to the more practical details of his subject, he pointed out that owing to our limited knowledge of the chemistry of cement, it is necessary to resort to tests of a physical and mechanical nature in order that the user may be able to satisfy himself that the product he employs will meet the demands laid upon it. From their nature, such tests must be arbitrary and, to ensure uniformity, must be carried out under standard conditions which will satisfy the requirements of the consumer and not lay too heavy a burden on the producer. Mr. Blount demonstrated the method of mixing the cement to be examined, on which so much of the reliability of the tests depends—a point which was illustrated by the story of a firm who undertook to subject a cement to mechanical tests and reported that a briquette had been made and had been found to contain a large number of voids.

After thus outlining a few of the intricate problems that may be presented to the technical adviser, Mr. Blount sketched out a course of training for those intending to specialise in the subject. After a broad elementary education he insisted on a sound general knowledge of Chemistry supplemented, if possible, by some mechanical and engineering training, before attempting to proceed to a postgraduate training in the chemistry of cement. This should be gained in a laboratory within easy reach of some centre of the industry where access to works can be obtained, in order that the student may be able to free himself from the small details of laboratory practice and grasp the broad principles, technological and economic, that underlie success in any chemical manufacture.

NEW METHODS OF ANALYSIS.

By HARLEY KNIGHT, F.C.S.

AFTER the various methods for the analysis of Raw Rubber have been reviewed, including the Nito naphthalene, Nitrosite and Tetrabromide processes, it is doubted whether after all for general practice the following is not the safest and quickest to adopt.

Five grams of the finely shredded Rubber is weighed into a tared Gooch crucible which has been previously prepared with a false bottom of suitable filtering material, such as cotton wool or filter paper covered with a depth of purified Kieselguhr, and is placed in an ordinary Soxhlet extractor, or better, one of the many new devices now specially made for the purpose, and the Resins extracted with Acetone. The residue, after having made sure that the Acetone extraction has been complete, is extracted with Benzene, which, on evaporation, gives the amount of Caoutchouc originally present in the sample, but perhaps the shortest and easiest method is to weigh the Resins and the insoluble matter, estimate the moisture and Albuminoids by the Kjeldahl method, when

Caoutchouc = 100 – (Moisture + Insoluble matter + Resin + Albuminoids.)

Volumetric Estimation of Tungsten.—The following method of estimating Tungsten should prove a very useful one, especially as the presence of Ferrous Iron does not interfere.

The process is one of reduction followed by oxidation by a standard solution, the following re-actions being involved :

$$WoO_3 + 4HCl + H_2 = WCl_4 + 3H_2O\ ;$$

$$WoCl_4 + 2FeCl_3 = WoCl_6 + 2FeCl_2.$$

A Standard solution of Ferric Alum is used with Potassium Thiocyanate as indicator, the solution of the Tungstic Acid in strong Hydrochloric Acid is reduced by Zinc and a current of Carbon Dioxide passed during the titration.

It should be noted in the reduction with the Zinc that the contents of the flask almost immediately become intensely blue, and this colour persists for some time, giving way for a few moments to a Permanganate hue and ultimately yielding a brown solution which is indicative of $WoCl_4$.

On titration the reverse changes occur and the reformation of the blue colour may be used to indicate the end of the titration instead of the red produced by the Thiocyanate.

For Tungsten steels and commercial Tungstic Acid (as used for metallic filaments in incandescent electric lamps) the process is very useful, but for Ferro-tungsten it is necessary to first fuse the finely powdered sample 0·1 gram) with about 4 grams of Potassium Sulphate over a Bunsen for about 20 minutes or until no particles of metal are visible.

The melt is dissolved in water, made alkaline with Caustic Soda, the Ferric Hydrate filtered off and the Tungsten estimated as before.

The authors give results showing that the process is capable of giving results in very close agreement with the truth. (Edmund Knecht and Eva Hibbert, *Analyst*, 1911, pp. 96-98.)

COMMERCIAL AND GENERAL NOTES.

The Potash Discoveries in America.

The recent announcement by the American Secretary of Agriculture that enormous deposits of potash had been discovered in Maryland, created a great amount of interest among American consumers and importers. The hopes of the consumers were centred around the possibility that a way out of the dispute over the German contracts was in sight, as the large deposits promised to make them independent of Germany. The people in the trade, as well as the scientists of the Geological Survey, assumed an attitude of scepticism, basing their doubts on the assumption that if there were any valuable deposits in Maryland existent, they would have been discovered long ago. They acknowledge the existence of certain feldspar deposits in that locality but deny their value to the fertilizer trade, as no process is known by which the potash in the feldspar could be made soluble.

An interesting development in this connection is the announcement that a large corporation has been formed for the purpose of working the Maryland deposits. The company is alleged to operate with a capital of not less than ten million dollars, and it is to be managed so as not to come into conflict with the Sherman anti-trust law. It is proposed to establish shortly four plants with a capacity of 500,000 tons a year, and four others are planned to double their capacity. All the capital is said to have been subscribed, and no stock is offered to the public.

Considering the operations of this new concern amount merely to the purchasing of about 5,000 acres and the erection of some manufacturing plants, the huge capital subscribed seems to be quite out of proportion to the possible requirements. However, the development of the potash problem will be watched with keen interest by the chemical industries of the old and the new world.

Development of Germany's Indigo Export Trade.

There are but few articles of commerce which can show a similar rate of development as artificial indigo. The trade in this product of the highly developed German chemical industry has within a short period assumed huge proportions. Since German artificial indigo was first exported, which took place in 1897, the quantities shipped have increased with great rapidity until they represent now almost forty times their original volume. The value of the exports amounted to some 40 million marks in 1910, and 1911 has probably seen a further increase, as during the first half of the year the value of the shipments represented already 23,500,000 marks, or 3½ millions more than during the corresponding period of 1910. The most important market for German indigo is China, which has ousted Japan from the position in the front row. In consequence of the raised import tariff on synthetic indigo in Japan, a further decrease of her imports is likely. The United States take the third position of importance as a market for artificial indigo. The United Kingdom, Austria-Hungary and Egypt are other big consumers, and it is interesting to learn that even British India, which might be considered the home of the natural indigo industry, is a fairly good customer of the German exporters of the synthetic dye. The partial loss of the Japanese market, and the interruption of the trade with China will cause the German manufacturers to renew their efforts in other markets, and it would not be surprising if they tried to capture another slice of the English trade in natural indigo, the United Kingdom being the nearest open market with a large demand.

The question whether synthetic indigotin is entitled to be called artificial indigo has recently been raised for discussion in the *Indian Planters' Gazette*. A writer who takes strong exception to the use of this name advocated the abolition of it from all descriptions of artificial dyes, even going so far as to suggest the introduction of a Bill in Parliament.

American Efforts to foster Export Trade.

British exporters of chemicals will be interested to hear that the Bureau of Manufacturers in Washington is making arrangements to use effectively the great mass of information that has been collected by the commercial agents of the United States within recent years. This information is to be presented to the public through the commercial organizations throughout the United States. Preliminary to this work, the department is now engaged in assembling all possible obtainable details regarding the number and operations of commercial organizations.

The recent return of the Commercial Agent of the Department of Commerce and Labour, and former head of the Bureau of Manufacturers, from an extended tour through Europe, will be followed by a series of meetings of business men, manufacturers, exporters and representatives of commercial organizations in different parts of the country, when the Agent of the Department will meet those interested in obtaining detailed and in many cases confidential information which has been obtained abroad. Many of the points ascertained are of such character as to be fit for communication direct to business men and exporters rather than in any form of publication. Among other countries of the old World, such as Germany, Denmark, France, Italy, etc., the Agent chose also Great Britain as a field for minute study, and as he proceeded with great energy and skill, our exporters and chemical merchants may be sure that he made the best of his opportunities. This progressive policy of the American Government ought to serve as an example *which our own Government* would do well to follow.

Growing Importance of Sulphate of Ammonia.

The producers of sulphate of ammonia have succeeded in demonstrating very effectively the development of their industry at the French Industrial Exhibition at Roubaix. The growth of the world's production of this important article is clearly shown by the following figures :—

1860	2,000 tons.
1900	450,000 ,,
1905	625,000 ,,
1910	1,100,000 ,,

The latter quantity is made up as follows :—

Germany	383,000 tons	France	57,000 tons
Great Britain ...	369,000 ,,	Belgium	36,000 ,,
United States ...	116,000 ,,	Spain	12,000 ,,
Austria	70,000 ,,	Italy	12,000 ,,
Japan	4,000 ,,	Netherlands	5,000 ,,
		Others	36,000 ,,
			1,100,000 tons

The consumption of the different countries is by no means identical with their production. Taking a fixed area in the four European countries—viz., France, England, Germany and Belgium—the proportion is as 1 : 2 : 4 : 10.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

18176/10. G. WILTON, London. *Treatment of Coal Gas.* 30 July, 1910.

According to this invention, the hot crude gas from the hydraulic main is led through an apparatus in contact with gas liquor and tar condensed from the gas and passing in the opposite direction through the apparatus and the liquor and constituents deposited therein are cooled at or towards the gas outlet end of the apparatus, so that this part acts as a condenser, the cooled liquor passing on in contact with the hot gas through a non-cooled portion of the apparatus at and towards the gas entry whereby light benzols, hydrocarbons and ammonia deposited in the cooled portion are again vapourised by the hot gas and pass on therewith. (5 claims, 3 Figs.)

19024/10. A. JARRAUD, Cognac. *Ageing Beverages.* August 12, 1910.

Wines, spirits and liqueurs are aged and improved by passing Hertzian waves through them. The waves are generated in an apparatus, which is immersed in the liquid to be aged, and comprises an ebonite tank containing a liquid dielectric and fitted with a glass cover and projecting ebonite tubes, which are perforated at the top to allow of escape of vapours. Insulated leads pass down the ebonite tubes to an oscillator consisting of aluminium balls acting as capacities connected with balls between which the sparks pass. (3 claims, 1 Fig.)

19141/10. E. J. HENRY, London. *Ammonium Nitrate.* 15 August, 1910.

Ammonium nitrate is prepared by mixing solutions of ammonium sulphite and calcium, barium or strontium nitrate. Calcium, barium or strontium sulphite is precipitated and separated, and the remaining portion of the calcium salts in the solution can be removed by the addition of the exact amount of ammonium oxalate. The purified solution is concentrated until it has a boiling point of 125°C., when it is allowed to cool, and a portion of the ammonium nitrate separates out. The nitrate so obtained is suitable for use in safety explosives. The mother liquor may be used to dilute a further quantity of calcium nitrate solution to be used in the process. If the nitrate solution contains an appreciable amount of magnesium nitrate, this can be removed by the addition of the necessary amount of strong ammonia solution, or milk of lime, or the corresponding hydrate. (4 claims.)

24790/10. F. E. MATTHEWS and E. H. STRANGE, London. *Synthetic Caoutchouc.* 25 October, 1910.

Caoutchouc and the like is produced from divinyl and from isoprene and from homologues or derivatives of each of these by acting upon them with an alkali metal, or an alkaline earth metal, or an alloy or mixture or amalgam of any of such metals with another or others of the said metals or with other metals. Metallic sodium or potassium are especially suited for the purposes of this invention. (1 claim.)

25100/10. SIR J. W. SWAN, Warlingham, and J. A. KENDALL, Streatham. *Manufacture of Sodium and Potassium.* 28 October, 1910.

The manufacture of sodium or of potassium is effected, according to this invention, by decomposing soda or potash, or carbonate of sodium or potassium at a high temperature in an upright nickel retort, containing incandescent carbon, and enclosed in a furnace to maintain the desired temperature, the alkali or carbonate being fed in a molten state into the retort at or near one end so that it passes through the incandescent carbon, the vapours of alkali metal produced passing off and being led to a condensing arrangement. (5 claims, 3 Figs.)

26788/10. J. C. MOULDEN and H. W. WEBSTER, Seaton Carew. *Zinc Distillation.* 17 November, 1910.

In the distillation of zinc according to this invention, a haloid salt, such as sodium chloride, is brought into contact with the retort vapours. This agent, in the presence of carbonic oxide, will prevent the formation of zinc oxide and "blue powder." (6 claims.)

27283/10. S. DE MEDVECZKY, Buda Pest. *Collodion or Celluloid Composition.* 23 November, 1910.

The invention relates to a process for the production of a material to some extent possessing both the properties of glass and of celloidin or celluloid. This material is produced by boiling in a concentrated solution of sodium or potassium silicate or any other salt containing silicic acid which is soluble in water, fresh celloidin which has been cut into small pieces or grated, until the solution has become saturated with the celloidin. The liquid is kept boiling for a short time thereafter, and to the solution there is added a metal oxide having a strong affinity to silicic acid and slightly soluble in water. It is also preferable to boil quartz powder with the solution so that the free alkalies therein may be chemically bound as far as possible. Also, if desired, resinous material, such as gum copal, may be boiled with the solution when a high polish is desired. (6 claims.)

29839/10. A. B. PESCATORE, London. *Production of Zinc.* 22 December, 1910.

The production of zinc from ore is effected by reducing the ore in a zone traversed by a non-oxidising gas, consisting mainly of carbon monoxide and nitrogen, and of which zone the temperature is increased by electric means. The zone is arranged sufficiently remote from the place in which the air used for the production of the carbon monoxide is first brought into contact with incandescent carbon to ensure that no substantial proportion of carbon dioxide reaches the zone of reduction. (5 claims, 2 Figs.)

8468/11. K. KOENMAN, Liege. *Preservation of Wood.* 5 April, 1911.

Under this invention, the wood is treated with a concentrated ammoniacal solution which neutralises the organic acids and decomposes the nitrogenous substances in the hardened sap and the resinous matters in part also so as to render them soluble in water. The solution penetrates right into the mass of the wood without destroying the fibres. The wood to be treated is piled in baths containing a concentrated ammoniacal solution, concentrated to from 16 to 17 per cent. for wood of about one inch thick, and to from 22 to 26 per cent. for wood of greater thicknesses. The wood is thereafter washed with water, which is constantly renewed, in order to carry away all soluble matter, and then is dried. The final washing may be effected by tepid water containing 0·5 to 1 per cent. of salicylic acid. (1 claim, 2 Figs.)

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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INDUSTRIAL SCHOLARSHIPS.

IT will be remembered that at the time of the last International Congress of Chemistry, which was held in London, Prof. Kennedy Duncan lectured before the Society of Chemical Industry on his scholarship scheme, which in its essence is intended to bring the manufacturer in touch with the student, while acting under the personal direction of the Professor of the Chemical Department.

This, as originally put into operation in the Kansas University, and since extended under the same supervision to Pittsburgh University, is one which may, or may not, be workable under European conditions. In America the manufacturer signs an agreement under which he supplies the student with a sum (which may amount in some cases to £400—£500 per annum) for personal expenses. In addition, the student may receive a percentage payment on contingent profits, in the event of the research disclosing practical results. The student is then guaranteed a permanent position in the works, and has charge of any industrial application connected with any developments of the investigation.

The actual working conditions are controlled by the College staff, and separate laboratories have been fitted up to meet the necessary working conditions. To this extent the University directly facilitates, and takes part in, the conduct of such research. As stated, the student is under the immediate supervision of the acting Director of Industrial Research, who has complete control over the student and completes the necessary arrangements with the manufacturer.

This scheme is an original one, and might under less satisfactory or more difficult conditions of working fail. Anyone who knows Prof. Duncan will recognise that he is an organiser of remarkable ability and the possessor of great tact. He is to be congratulated on the fact that he had the opportunity of launching this scheme under the best conditions, and has succeeded in obtaining the necessary co-operation of a number of American manufacturers.

Many of the subjects chosen for research may seem to European chemists to be of a somewhat general nature, but it is always difficult to criticise American conditions from this side of the Atlantic, especially when it is remembered that these have not yet crystallised into any final form.

The Chemistry of Laundry Work, Study of Diastase, Chemistry of Bread, Utilisable Constituents of Crude Petroleum, Enamelled Lined Steel Tanks, Physical Properties of Glass, Utilisation of Borax, Manufacture of Soap, Abatement of Smoke Nuisance, Chemistry of Cement, Utilisable Substances from Natural Gas, are among the subjects already in hand.

The success of the scheme is such that it has already been extended to Pittsburgh. Where, as we understand from a recent communication, no less a sum than £8,000 per annum is being contributed to the scheme for the student's personal expenses. On an average the term of investigation seems to be for three years.

Prof. Duncan works on with all the enthusiasm of an originator of a scheme which has reached the working stage. He claims that the results already obtained fully justify the scheme and its inception. This seems to be so when working under American conditions,—and may we add, the guiding hand of its originator.

It remains to be seen whether the scheme could ever have an equal chance of success in the older industrial centres of Europe. Even if this should not be the case, the experience of those who find that it meets local conditions in America, where it apparently succeeds in bringing the general claims of the chemist more fully before the manufacturer, will be of interest. In the long run the actual results obtained in practice may still further emphasise the nature of the different conditions on the two Continents. When once the American manufacturers find that they must employ chemists, this college-aided scheme may have less significance than at the present time. In the meantime we may wish success to this venture, and its originator, and watch its progress with the interest it deserves.

The Chemist and Cancer.

It has been thought by some that the ultimate triumph in the cure or prevention of this dread disease may rest with the chemist. According to Dr. E. F. Bashford (*Lancet*, No. 4611, p. 112), the past results with radium and adrenalin have proved disappointing. However, the results obtained by A. von Wassermann, in Berlin, may, in the opinion of such an authority as that quoted, have far-reaching effects. The substance used is one containing eosin in combination with selenium. The colour of the compound serves a definite purpose. The metallic compound seems to exhibit a selective affinity under the conditions of the test for the affected area. The substance itself is a dangerous poison. In one case four mice out six were killed by the treatment, *but the other two were cured*. This is stated to be the inevitable result where the mice can withstand the treatment. The results obtained, so far as they go, indicate "that a chemical substance can be prepared, which, when injected into the blood stream has an elective affinity for tumour cells, injuring and killing them, while sparing the rest of the body."

It should not be beyond the power of the chemist to modify the properties of this compound, and bring it under control. The use of certain organic compounds of arsenic and selenium certainly seems to have a future before it. The chemist can probably suggest means, as has already been done in the former case, to control the action of such a powerful reagent, as the one used by von Wassermann. Past work in other directions clearly points to this being possible. It may be that selenium in a colloidal state will be of value, especially as colloidal solutions of the metals have recently been found to be useful, owing to their stimulating effect on phagosytosis and their destructive action on micro-organisms and their toxins.

The increasing use of colloidal solutions of metals in therapeutics is very noticeable, and the results obtained seem to be of a definite and satisfactory nature. Such colloidal solutions are even injected into the spinal canal, or may be applied to the surface of the diseased membranes. It is interesting to note that this colloidal solution of metals has been used effectively with such widely diverse diseases as pneumonia, puerperal fever (where the electrically prepared colloids yield brilliant results), typhoid fever, erysipelas, and tonsilitis. The great point claimed is the absolute innocuousness of these colloidal bodies to the human system.

* * * * *

The Closed Ring.

The series of articles we are publishing on the facilities which exist for special instruction in the colleges in this country, is one which may well draw attention to one point. It would seem that in some cases, such as that of the Leather Industry, the students passing through the departments are practically all connected with the industry before they enter the college.

In this way it happens that comparatively few students are subsequently available for general posts. In this way the demand may often be in excess of the supply.

This should certainly be remembered by those entering Chemistry as a profession. It is understood that a similar condition exists in a special department dealing with Paper-making in the North. In the days of crowded professions this point is one which may well deserve special attention. The facilities which exist to-day for such special instruction, are in many directions highly satisfactory, and when combined with a thorough training in the general principles of chemistry, must give the young student a training which cannot fail to play a distinct part in future industrial progress in this country. There is always room for such highly trained men as assistant managers and chemists in this country and the Colonies.

We shall be glad to draw the special attention of our readers to any further examples of this nature which may be brought to our notice.

* * * * *

Kinematograph in College and School.

It is interesting to note the discussion at present being carried on respecting the possibility of using this invention as a medium for educational purposes. Films of subjects have been exhibited which deal with industrial operations, and in many cases these certainly afford an object-lesson of the conditions which obtain in industrial operations. In elementary lessons on industrial chemistry, the collecting of raw products and the processes which are conducted in a factory might be shown in class in our higher schools and colleges with advantage. The recent results obtained and exhibited in the hospitals for the instruction of students has apparently served their purpose. Under present conditions the cost of these special films stands in the way of their extended use, and it would seem that concerted action on the part of those interested will be necessary if a suitable supply of films is to be available. That these would have a distinct value, and appeal to the imagination of the scholar and student, cannot be gainsaid.

The almost complete absence of any general knowledge of the conditions under which the chief industries of this country are carried on is to be deplored.

For example, how many have any knowledge of the processes involved in the manufacture of "Shoddy," which enters largely into the cloth materials used by the lower and middle classes. This absence of general information may be regarded as sufficiently serious for a welcome to be extended to any method of disseminating such knowledge; and by the aid of this invention this end might be attained in a satisfactory manner.

THE RECENT DEVELOPMENT OF BIOLOGICAL CHEMISTRY.

By A. HARDEN, D.Sc., F.R.S.

THE term "biological chemistry," abbreviated in conformity with the prevailing desire for brevity to bio-chemistry, has been introduced to designate that branch of science which deals with chemical change as effected by the living organism. The subject may fairly be considered as worthy of a special subdivision of science, although it shades off by imperceptible degrees on all sides into other closely allied branches.

The distinction between the chemistry of living and dead matter is of very ancient standing, and finds a still existing memorial in the terms "organic" and "inorganic" chemistry, which, like the rudimentary organs of animals, mark a stage in the evolutionary history of the subject.

The original idea that the obvious chemical changes and the obscure chemical compounds characteristic of the world of living organisms were due to the action of forces different in kind from those which prevailed in the realm of living matter, received its death-blow when substances hitherto unobtainable, except by the action of nonliving organisms, were first prepared in the laboratory. The syntheses of alcohol and urea, by Hennell and Wöhler, in 1828, finally settled the question whether the products of animal and vegetable life could or could not be artificially prepared. No one any longer doubts that all the substances present in animal and vegetable organisms are capable of being synthetically prepared in the laboratory, and will one day be so prepared. We are, however, far from the realisation of such a scientific victory in all its details, although the outposts of all the main positions have been stormed, and a numerous and well-equipped army of invasion is making a steady and irresistible advance upon the citadel. Herein lies one of the main problems of bio-chemistry—the synthesis of the chemical substances which form the basis of living matter.

The first synthesis of products of the organic world, however, served at the same time to accentuate the great distinction between the methods adopted in the laboratory and those available in the organism. To produce alcohol, ethylene was passed into concentrated sulphuric acid and the resulting liquid then diluted and distilled. In the vine, the necessary sugar is synthesised from carbon dioxide and decomposed in the ripe grapes by yeast cells, which have found access to their external surfaces—all these processes being carried out in aqueous solution at the temperature of the air.

This, however, is a well-worn theme, and need not be further elaborated here. It was early recognised that many of the reactions of the living organism took place under the catalytic influence of unstable substances termed enzymes, and the epoch-making work of Buchner on yeast-juice, in 1897, admitted an entirely new class of bio-chemical changes, previously considered inseparable from the living organism, to the same category of enzyme actions. The influence of enzymes, at first thought, without logical foundation, to be limited to reactions of decomposition, accompanied by liberation of energy, is now, as the result of Croft Hill's researches, known to extend to synthesis as well as decomposition. The thesis may in fact be maintained, although the evidence does not yet amount to absolute proof, that all the chemical processes of the living cell are influenced by the presence of enzymes.

The problems connected with these mysterious agents are among the most important, and, it may be added, the most fascinating which await solution at the hands of the biological chemist. Every day brings further information as regards the marvellously complex mechanism of enzymes, co-enzymes, anti-enzymes, etc., with which even the simplest cell is provided in order to accomplish with certainty, and at the right moment, the chemical changes on which the continuance of its existence depends. Doubtless, even the enzymes themselves will one day fall under the dominion of the synthetical chemist, but hitherto even their chemical character remains unknown.

The study of the conditions of chemical change in the living organism has led, however, not only to the recognition of the fundamental importance of the agents by which these changes are rendered possible, but also of the conditions under which they are actually carried out. The fact that the enzymes themselves, and many of the substances on which they act, are present in the colloidal state, has inspired much of the recent work on the nature of colloids. A new science—the chemistry of colloids—is rapidly being developed, and phenomena of the most varied kinds affecting all branches both of pure and applied chemistry are being recognised as due to the influence of the state of division of the matter participating in them. It is now being understood that absorption according to an exponential law is not less important than combination by simple multiples. After a century of neglect, the views of Berthollet are being brought into the light and placed on an equality with those of Proust.

Since we are dependent, not only for our food, the prime necessity of life, but also for a large part of our comforts and luxuries, on bio-chemical changes, the importance of as full an understanding of these as is possible, can easily be realised. Those concerned are becoming aware of the possibilities thus presented to them, and increasing advantage is being taken of the results of recent bio-chemical investigation in many branches of industry in which biological factors are involved, notably in agriculture, brewing, sewage disposal, water supply, etc. Enzymes and organisms are moreover being harnessed in the service of industrial chemistry, and although progress in this direction is likely to be limited by the small range of variation in the experimental conditions of which such agents permit, increasing use will doubtless be made of them for specific purposes.

The influence of all these discoveries on our ideas as to the mechanism of life can scarcely be exaggerated. Although the fundamental secret of the nature of life still remains, and in all probability will long remain hidden from our inquiring eyes, much of what was even quite recently regarded as vital and inseparable from living matter has been proved by careful experiment not to be so, but to depend on conditions which can be realised apart from the living organism. How far this process can be carried, it remains for the future to reveal—the limits are not yet in sight.

ANTHRAX IN THE INDUSTRIES.

By Constant Ponder, M.D., D.P.H.

A certain responsibility must devolve upon the employer of labour whose men contract disease, the cause of which is intimately associated with the material handled in their work. That the gravity of such responsibility is realised by those whose workmen are liable to Anthrax, is shown by the efforts made to overcome the difficulty. In Bradford, where woolcombers and others may contract this disease, the manufacturers have formed an Investigation Board, and a bacteriologist is retained to inquire into all cases that occur, and if possible find out suitable preventive measures. Though entire success has not yet been met with in this direction, useful work has been done in scheduling the more dangerous goods; it has also been definitely proved, that clots of blood that are sometimes found matting together the wool, are the greatest source of danger, and if goods containing these are destroyed the major part of the risk is avoided. There is no doubt, however, that a disinfecting fluid which will effectively destroy the spores of *B. Anthracis* without injuring the wool is urgently needed.

Anthrax is also liable to occur in the tanyard and docks, amongst men who handle hides and skins imported from the Far East and other places, where no control is exercised over the disposal of carcases of animals dead of Anthrax. This aspect of the question has also received wide attention. The problem presents many difficulties: firstly, the spores of *B. Anthracis*, themselves very resistant, are protected by being enclosed in an albuminous coat of dried blood or similar substance; secondly, tanning is a somewhat delicate process, and the application to the surface of the skin, of a strong chemical, calculated to destroy the spores, will probably enormously depreciate its value as leather.

For these reasons the commonly-used disinfecting processes, such as the application of heat, Formaldehyde, coal-tar products and Perchloride of Mercury are unsuitable. To destroy the spore by moist heat, it is necessary to boil the infected material for several minutes; needless to say this would utterly ruin a raw skin. Formaldehyde has a premature tanning action, even in weak dilutions—a method of tanning is actually in use which depends on this property—emulsions of coal-tar disinfectants are probably not sufficiently penetrating, whilst Perchloride of Mercury used alone forms insoluble albuminates with animal matter, and its germicidal activity is proportionately diminished.

Hides and skins are imported in different states, but these may be roughly divided into "dry" and "wet-salted." The "dry" variety includes all those which have been preserved by drying in the sun or wind, or by having earthy materials rubbed in on the flesh side; the "wet-salted" variety includes those which have been treated with salt or brine, which, by its hygroscopic nature, prevents thorough drying from taking place. It has been found that the "dry" hides and skins have been responsible for nearly all the cases of Anthrax due to this cause, and the reason is, no doubt, that they are always accompanied by dust, ready to rise in clouds when the goods are handled; this dust gains access to the surface of the skin of the face and neck, which seem the especially vulnerable parts, and then, should it harbour spores, the disease is liable to be set up by their being scratched in, or inoculated in some other way, such as when shaving.

It is clear that it would be a great safeguard if all hides were imported in the "wet-salted" state, but under present conditions this is not practicable.

A suggestion has, however, been made by a practical tanner that all "dry" hides and skins should be converted into "wet-salted" at the ports of shipment, and that this should be accomplished by soaking the goods in a 1% solution of formic acid for 24 hours; by this means the "dry" hides would be thoroughly softened, so that if then salted, they would be in almost exactly the same condition as if they had been so treated immediately after being removed from the animal's back. At the same time, as an additional safeguard, it is proposed to add a small quantity of Perchloride of Mercury (say one part in five thousand) as a sporicide. The combination of Perchloride of Mercury and the weak acid is particularly useful, because the acid swells and hydrates all the albuminous material protecting the spores, and thus allows the mercury to permeate the material completely, and at the same time prevents the formation of insoluble albuminates.

Bacteriological evidence strongly supports the efficacy of this method, and judging by the reports of the leading leather trade chemists of this country no damage is likely to be done to the goods.

It remains to be seen whether this method is received favourably by the tanning trade. The disadvantages are, firstly, the expense, which, however, would not probably amount to more than 3½*d*. per full-sized hide, even in remote ports, and proportionately less for smaller skins; and, secondly, the change of technique necessary for those who have been accustomed hitherto to tan "dry" goods. On the other hand the advantages are, that the goods have been disinfected effectively without damage to the material, so that all risk to the men is abolished; the value of the goods in the raw state can be more correctly estimated; and they are less liable to damage in the early stages of tanning when started as "wet-salted," than when they have to be "soaked back" from the "dry" state and putrefaction is likely to give trouble.

This method appears to merit the careful consideration of the tanning world, for I believe that were it found possible to adopt it as a routine treatment for all "dry" hides and skins coming from dangerous areas, such as China, the Straits Settlements, India, the Cape and West Africa, we should hear no more of Anthrax among workmen employed in this industry.

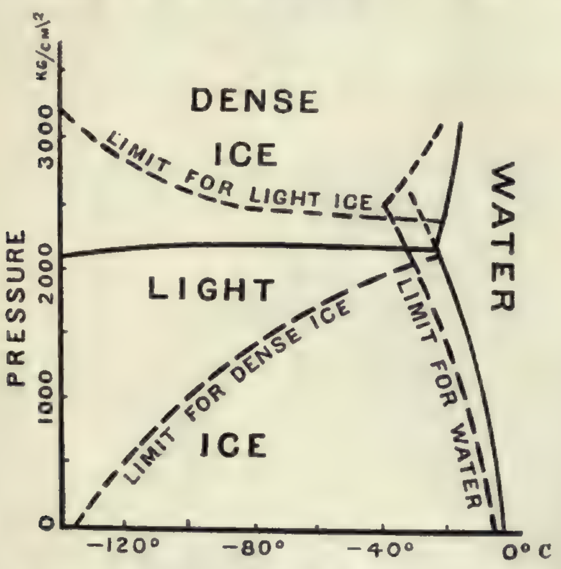
ICE, WATER, AND STEAM.

By T. Martin Lowry, D.Sc. (Lond.).

In discussing the "three states of matter" it has been customary in text-books, both of chemistry and of physics, to refer to water as the typical liquid. In many respects no choice could be more unfortunate, since no liquid is known which presents so many anomalies or deviates so widely from the general type. Thus, its boiling point is at least 200° too high for a liquid, whose nominal molecular weight is only 18; its specific heat is almost twice as great as that of all other liquids, and presents the unique anomaly of passing through a minimum value at 25° (see the recent Paper on "The Specific Heat of Water," by W. R. and W. E. Bousfield, *Phil. Trans.*, 1911, A, *211*, 199); its power of combining with and dissolving salts is imitated only in a feeble degree by two or three liquids, such as liquefied ammonia; and, finally, the electrical conductivity of its solutions remained a unique property for nearly a century, until similar properties were detected in a few curious solvents, such as NH_3, SO_2, HCN and $H{\cdot}CO{\cdot}NH_2$, the last substance (formanide) being the closest imitation of water that has yet been discovered.

It was, however, the well-known anomaly of a maximum density at 4°C, coupled with the increase of volume on solidification, that led Prof. Röntgen, of Vienna, just 20 years ago (*Wied. Ann.*, 1891, *45*, 91), to suggest that water was not a simple substance, but a mixture. The two ingredients were described as "water-molecules" and "ice-molecules," the latter being supposed to be more complex but less dense, so that their decomposition, both during fusion and during the subsequent warming of the ice-cold water, was accompanied by a contraction of volume. Röntgen's theory as to the constitution of water has been generally accepted by subsequent workers, and has afforded an explanation of nearly all the anomalous properties of the liquid. To give only one example, the high specific heat of water follows naturally from the fact that heat must be supplied not only to heat the different kinds of molecules present in the liquid, but also to bring about the dissociation of the more complex into the more simple types; and, as this dissociation is most rapid at the lowest temperatures, it is only natural that the specific heat should be exceptionally large in the neighbourhood of the freezing-point.

In seeking for a fitting sequel to the article on ethyl acetoacetate, which occupied the corresponding column of the January issue of this Journal, the writer came to the conclusion that he could not do better than to refer to the fact that modern equipment for work at low temperatures has rendered possible the actual isolation of two constituents from water, as well as from the much-discussed ester described by Dr. Clayton. The production of ice from water has been recognised, since the appearance of Röntgen's paper, as involving the separation in a pure state of one of the constituents of water; but in accordance with the well-known law which governs reversible chemical changes, the other constituents do not accumulate in the unfrozen liquid, but remain in constant proportions there, until the end of the freezing causes them to pass completely into the "ice-molecules" of ordinary solid "Ice I." The second constituent of water is obviously denser than the first; if it could be isolated in the liquid state it would be denser than ordinary water; its density in the form of ice would be greater still. This dense variety of ice is only formed under pressures exceeding 2,000 atmospheres. Under such a pressure the freezing-point of water is lowered to – 22°, to which temperature the liquid must be cooled in order to prepare the dense "Ice III."; the working pressure usually required is about 3,000 atmospheres, although the dense variety is stable at all pressures above 2,150 atmospheres. On releasing the pressure the dense "Ice III." is at once converted into light "Ice I."; but as the temperature is lowered it becomes possible to reduce the pressure to some extent without producing any immediate change in the ice; finally, at temperatures below – 130° the whole of the pressure can be removed from "Ice III." without causing it to change. By making use of liquid air, therefore, it is possible to prepare the dense ice in a form in which it can be seen and handled—a far more satisfying procedure than merely to infer its presence from the readings of a pressure-gauge!



To prepare "Ice III.," water in an oiled paper capsule is compressed by means of oil to a pressure of 3,000 kg/cm², *i.e.*, about 2,900 atmospheres; the compression cylinder is cooled to – 80° by means of carbon dioxide, and then to – 180° by means of liquid air. On releasing the pressure the capsule is found to contain a small block of ice, which sinks instead of floating when dropped into liquid air; but when removed from the liquid air and allowed to warm up to – 130° the clear mass of dense "Ice III." swells up and crumbles into a bulky powder of light "Ice I."

The figure reproduced above is taken in a slightly modified form from the paper (*Zeitsch. physikal. Chem.*, 1910, *72*, 609) in which the preparation and properties of this novel form of ice are described by Prof. Tamman. The firm lines show the limits of stability of water and of the two varieties of ice. Beyond these limits each form in turn ceases to be stable, but can maintain a precarious existence in a "metastable" condition. The extent to which such trespassing is possible is shown by the dotted lines, beyond which conversion to the stable form at once takes place.

There can be little doubt that Tamman's "Ice I." and "Ice III." actually correspond with Röntgen's "ice-molecules" and "water-molecules," and their preparation and presentation in concrete, visible form is thus a matter of no small interest and importance. But the problem is by no means completely solved thereby. Thus Tamman has shown that if dense ice be prepared by freezing water and then compressing, the product is not identical with the "Ice III." prepared by compressing first and freezing after; the new variety of dense ice, which is described as "Ice II.," is very similar to "Ice III.," and is probably composed of the same molecules built up into a different crystal structure. In the same way, if ice be frozen under a pressure of 500 to 2,000 atmospheres the propressing first and freezing after; the new variety of light ice, to which the name "Ice IV." has been given; this appears to be merely another case of "polymorphism," *i.e.*, of similar molecules being built up into different crystal-structures.

As regards the liquid, it has been widely recognised that Röntgen's view is too simple to represent all the complex properties of water. The writer, in conjunction with Mr. W. R. Bousfield, has advocated the view that "Liquid Water is a Ternary Mixture" of "ice-molecules," "water-molecules" and "steam-molecules" (*Trans. Faraday Soc.*, 1910, *6*, 15), these three varieties being perhaps identical with Sutherland's "trihydrol" H_6O_3, "dihydrol" H_4O_2, and "hydrol" H_2O (*Phil. Mag.*, 1900 [v]. *50*, 460). Armstrong (*Proc. Roy. Soc.*, 1908, A, *81*, 80) has added to the theory the conception of isomeric molecules, of equal size but different structure, Sutherland's "dihydrol" H_4O_2 being replaced by a mixture of

"dihydrone" $^{H}_{H}\!>O{=}O<^{H}_{H}$ with
"hydronol" $^{H}_{H}\!>O<^{OH}_{H}$

and so forth. Such extensions as these have been found to be necessary, in order to explain the experimental data that have been accumulated in recent years, and must now be regarded as essential parts of the theory of the constitution of water.

Even steam, so long considered as a uniform material that could be represented accurately by the much-beloved and greatly over-worked formula H_2O, has been shown by the careful measurements of Bose (*Zeit. für Elektrochem.*, *14*, 270) to be a mixture of simple and polymerised molecules, *e.g.*,

$$H_4O_2 \rightleftharpoons 2H_2O$$

the proportion of the substance in the simpler form being reckoned at 91% in the neighbourhood of the boiling-point.

Considerations such as these serve to show the extreme complexity of water in its various forms, and it is, perhaps, a matter for congratulation that its behaviour is so little typical of the majority of liquids which chemists are called upon to handle.

Simple Method for the Production of Pure Ferrocyanides of the Heavy Metals.

By HERBERT WILLIAMS, F.C.S.

THE production of pure ferrocyanides of the heavy metals free from the alkali metals by means of hydroferrocyanic acid is tedious and in some cases presents considerable difficulties, and repeated efforts were made by the author to produce pure insoluble ferrocyanides by the precipitation of a metallic salt with a solution of the alkaline ferrocyanides, but without success, although the method was varied in every possible manner, such as adding the ferrocyanide solution to a large excess of the metallic salt in the cold, mixing the solutions at 100°C., etc.

The carefully washed and dried precipitates obtained by any of these methods were almost without exception found to contain definite proportion of the alkali metal in combination. Experiments were then made with the alkaline earth ferrocyanides, and it was found that in precipitating calcium ferrocyanide solution with an excess of a solution of the chloride or nitrate of the metal of the desired ferrocyanide, pure products were obtained.

It is advisable to add the calcium ferrocyanide solution to an excess of the metallic salt solution, but the reverse procedure will also yield a pure product, if the metallic salt is in moderate excess.

The dried precipitates obtained by this method were found to closely resemble those obtained by means of hydroferrocyanic acid, and to differ in come cases most markedly from those obtained by precipitation with the ferrocyanides of the alkalies both in colour and appearance.

The most striking examples were the cobalt ferrocyanide and the manganous ferrocyanide, the first of which consisted of a green powder, and the latter small yellowish crystals.

Particulars are given of a few of the pure insoluble ferrocyanides prepared as follows :—

> To a solution of calcium ferrocyanide the chloride or nitrate of the desired metal—which of course must be pure and free from sulphate, etc.—is added in excess, the precipitate washed by decantation with distilled water, as much water as possible removed by the vacuum filter, and then dried at a low temperature.

Barium Ferrocyanide. $Ba_2Fe(CN)_6 6H_2O$.

Light yellow crystalline powder sparingly soluble in water readily decomposed by sulphates or carbonates of sodium, potassium or ammonium.

This compound can also be readily obtained pure by adding baric chloride solution to a strong solution of sodium ferrocyanide, washing the crystals and drying.

No baric sodic ferrocyanide appears to exist.

Cadmium Ferrocyanide. $Ca_2Fe(CN)_6 7H_2O$.

White insoluble powder, absolutely unattacked by the boiling carbonates of the alkali metals.

Cobalt Ferrocyanide. $Co_2Fe(CN)_6 9H_2O$.

Green compound, insoluble in water.

Cupric Ferrocyanide. $Cu_2Fe(CN)_6 10H_2O$.

Brown insoluble precipitate.

Ferrous Ferrocyanide. $Fe_2{}''Fe(CN)_6 XH_2O$.

White insoluble precipitate, rapidly oxidising in the air to form ferric ferrocyanide.

Ferric Ferrocyanide. $Fe_4{}'''(Fe''(CN)_6)_3 45H_2O$.

Dark blue compact masses with coppery lustre.

Lead Ferrocyanide. $Pb_2Fe(CN)_6 5H_2O$.

Heavy white insoluble powder.

Manganous Ferrocyanide. $Mn_2Fe(CN)_6 8H_2O$.

Yellowish-white crystallic powder not decomposed by the boiling solution of the carbonates of the alkali metals.

This compound differs entirely in appearance from that produced by precipitation of the alkali metal ferrocyanide by a manganous salt.

Nickel Ferrocyanide. $Ni_2Fe(CN)_6 18H_2O$.

Light brownish olive-green powder.

Zinc Ferrocyanide. $Zn_2Fe(CN)_6 6H_2O$.

White insoluble powder, only partially decomposed by boiling with the carbonates of potassium or soda, completely soluble in caustic soda or potash insoluble in ammonia.

The calcium ferrocyanide required for this method can be very readily made by the following process :—

Dissolve 484 grams crystallised sodium ferrocyanide in 2 litres of water and heat to the boiling point, then add a solution made by dissolving 111 grams fused calcium chloride and 107 grams ammonium chloride in the smallest possible quantity of water. A precipitate of the sparingly soluble calcium ammonic ferrocyanide is formed according to the equation.

$$Na_4Fe(CN)_6 + CaCl_2 + 2NH_4Cl = Ca(NH_4)_2Fe(CN)_6 + 4\,Na\,Cl.$$

The precipitate is transferred to a vacuum filter, thoroughly washed with distilled water; when washed the double salt is turned out of the vacuum filter to a large dish mixed with distilled water and boiled up with slaked lime, the lime being added from time to time as long as ammonia is evolved. When all the ammonia is driven off the solution of calcium ferrocyanide is filtered off, evaporated and crystallised.

The reaction of the double salt with slaked lime is as follows:—

$$Ca(NH_4)_2Fe(CN)_6 + Ca(OH)_2 = Ca_2Fe(CN)_6 + 2NH_3 + 2\ H_2O.$$

Calcium ferrocyanide crystallises in large crystals containing 12 molecules of water

$$Ca_2Fe(CN)_6 12H_2O.$$

The addition of cupric chloride solution in excess to a solution of calcium ferrocyanide produces a precipitate of pure cupric ferrocyanide, and experiments were made by the author to ascertain if it were possible to form a definite cupric calcic ferrocyanide. Cupric chloride solution was added to a solution of calcic ferrocyanide, taking great care that the latter body was maintained in large excess. The precipitate so obtained was washed by decantation with cold distilled water, placed on a vacuum filter and as much water as possible removed, then dried at 30-40°C. The compound so obtained consisted of a light brown loose powder with a composition corresponding to the formula:

$$CuCaFe(CN)_6 12H_2O.$$

On heating this compound to 100°C. it looses eight of its twelve molecules of water and is converted into the compound:—

$$CuCaFe(CN)_6 4H_2O.$$

The colour changing from light brown to a magnificent violet, this change begins to take place at about 70°C.

If this violet compound is exposed to moist air it gradually reabsorbs the eight molecules of water and passes back to the compound $CuCaFe(CN)_6 12H_2O$, the colour at the same time changing back from violet to light brown.

This change can be rapidly brought about by moistening the violet compound with water, the colour instantly changing to brown with rise of temperature.

This remarkable dehydration and hydration can be repeatedly performed.

NOTES OF MEETINGS, &c.

THE INSTITUTE OF CHEMISTRY.

THE second Lecture by Mr. C. F. Cross, B.Sc., F.I.C., on Cellulose, will be given on February 23rd at University College.

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ROYAL INSTITUTION OF GREAT BRITAIN.

February 9th.—Very High Temperatures, by J. A. Harker, D.Sc., F.R.S. (with electric furnace experiments).

February 24th, March 2nd, 9th, 16th, 23rd, 30th.—Molecular Physics, by Prof. Sir J. J. Thanson, M.A., LL.D., D.Sc., F.R.S. (at 3 o'clock).

March 8th.—Origin of Radium, by F. Soddy, M.A., F.R.S.

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THE INSTITUTE OF METALS.

THE following officers were elected for the coming year—President: Professor Gowland; Vice-Presidents: Professor Carpenter, Mr. Summers Hunter, Professor A. K. Huntington, Mr. W. H. Johnson, Engineer Vice-Admiral Sir Henry Oram, and Sir Henry Wiggin; Members of the Council: Mr. L. Archbutt, Professor A. Barr, Mr. Bayliss, Mr. G. T. Beilby, Mr. G. A. Boeddicker, Mr. R. Kaye Gray, Mr. George Hughes, Dr. R. S. Hutton, Mr. J. T. Milton, Mr. Murray Morrison, Mr. G. H. Nisbett, Mr. Panizzi Preston, Dr. W. Rosenhain, Mr. A. E. Seaton, Cecil H. Wilson, and Professor T. Turner (hon. treasurer).

SOCIETY OF CHEMICAL INDUSTRY.

FORTHCOMING PAPERS.

LONDON SECTION:—Monday, February 5th, 1912, a discussion will take place on the Industrial Bursaries Scheme of the Commissioners of the 1851 Exhibition. (See Journal, 1911, p. 723.) March 4th, Dr. C. E. Kenneth Mees, "The Photographic Process."

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THE CHEMICAL SOCIETY.

THE Moissan Memorial Lecture will be delivered by Sir William Ramsay, K.C.B., F.R.S., in the rooms of the Chemical Society, on Thursday, February 29th, 1912, at 8.30 p.m.

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BIOCHEMICAL CLUB.

THIS club has been recently formed for the purpose of facilitating the interchange of ideas between biologists and chemists, who are interested in problems common to both, such as Agriculture, Brewing, Animal and Vegetable Pathology and Physiology. Meetings will take place at Oxford on May 6th; Harpenden on June 10th; University of London on July 8th. The Hon. Secretary is R. H. Adlers Plimmer, University College, London, W.C.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

Enzymes.

By E. Frankland Armstrong, D.Sc., Ph.D., F.C.G.I.

The marked advance in the knowledge of enzymes during the last few years has been by no means the least of the achievements of chemical science, and though it is not possible to indicate any particular discovery as marking a definite advancement, the general progress has been slow and sure. At all events, no branch of biological chemistry has been of greater importance in giving some clue to the fundamental processes of metabolism in life than the study of enzymes, and in this respect recent progress has been very definite. It will be the object of these notes to indicate from time to time the directions in which progress is being made, a task which will involve the consideration of the subject from a physical and biological as well as from the purely chemical side and often also from the technical standpoint.

Biologists now recognise that very many of the changes, if not all, formerly regarded as vital are brought about by enzymes, and the knowledge of the behaviour and properties of these agents is admitted to-day as of importance in many more industries than that of brewing. Progress in the main has been in three directions: in the first place, many new enzymes have been recognised and their specific functions established and classified; secondly, a great deal has been done to study the laws, especially the kinetics, of enzyme action; thirdly, it has been sought to establish their chemical nature and to gain some clue as to the manner in which they act in actual living matter.

As a result a considerable number of different enzymes are recognised, their outstanding characteristic being the essentially specific nature of their activity. As a rule, the very smallest change produced in the chemical structure of the substances on which enzymes act, suffices to render them no longer active and unable to bring about change.

It is some years since Emil Fischer first proved this in the case of the glucosides; more recently Abderhalden and his school have shown it to be equally true for the action of the proteoclastic enzymes on polypeptides, whilst Bertrand and others have shown that change of structure exercises a profound effect in modifying the action of the specific oxydases.

The laws of enzyme action are fairly clearly established: they are substantially in agreement with those of mass action, although complications are introduced by the sensitiveness of the enzyme to impurities, and the fact that it often does not remain constant during the change. New work in this branch of the subject is being published continually, generally without regard to most of what has been done before. In consequence a good deal of confusion prevails: it is proposed to make this the subject of a subsequent note.

The effect of light upon enzymes, more particularly that of ultra-violet light, is a matter of interest. The bactericidal influence of the ultra-violet rays has lately been the subject of much attention in France, and the attempt is being made to apply them industrially to the sterilisation of water. Agulhon (*Comptes Rend.*, 1911, *153*, 979) finds that the different enzymes vary in their resistance to light; some resist it except in the presence of oxygen, others are destroyed even in the absence of oxygen. Ultra-violet rays are much more active than the visible rays. The presence of impurities greatly influences the resistance of enzymes towards light.

Most of the changes in which enzymes act as catalysts take place with remarkably little production or absorption of heat. In consequence the energy losses when plants or animals draw on their reserve materials or build up as such are very small—an all-important matter. The latest measurements of this kind have been made by A. V. Hill (*J. Physiol.*, 1911, *43*, 261) in a newly designed form of micro-calorimeter, which promises to give valuable results in investigations of this character. He finds that the heat produced by the hydrolysis of 1 gram of starch to maltose by saliva is only 0·5 cal., which is but 1/10,000 of the total energy of the starch.

The effect of storage at 0° in increasing the amount of sugar in potatoes is well known; a recent paper by Müller-Thurgau and Orelli (*Biedermann's Zentr.*, 1911, *40*, 681) has thrown further light on this phenomenon, which is shown to be due to the fact that different enzymes are unequally influenced by changes of temperature. In the potato, three enzyme transformations are taking place simultaneously: starch is hydrolysed to sugar, sugar synthesised to starch, and sugar is transformed by respiration to carbon dioxide. All three changes are hindered by lowering the temperature, the hydrolytic enzyme being least of all affected. At 6° hydrolytic and synthetic changes are equal in intensity; at 0° the hydrolytic prevails, as much as 3 per cent. of sugar being accumulated; at 20° the synthetic and respiratory effects predominate. In consequence potatoes become sweet when frozen, but lose this sugar again and respire more freely when warmed. The unequal effect of temperature on enzymes is a fact of very considerable importance in physiology and one that at present, though known, has not been sufficiently emphasised. A fall of temperature has the effect of shifting equilibrium points of reversible reactions towards a greater concentration of the products of the exothermic direction of the reaction.

Progress in the direction of the purification of enzymes or gaining some clue to their chemical nature is very slow. The older view, that enzymes were proteins, has been gradually abandoned, as purification showed a progressive loss of nitrogen. The fact that enzymes are colloids and therefore able to absorb the constituents of the solutions from which they are precipitated makes purification exceedingly difficult. Another difficulty is caused by the loss of activity during purification, due possibly to the removal of bodies such as electrolytes and co-enzymes necessary for their full activity. The discussion of enzymes as colloids will be reserved for another occasion. Enzymes are not proteins, though they always contain some nitrogen. A carbohydrate appears to be an essential component in the case of invertase and diastase (a pentose), though Osborne identified diastase originally with the leucosine fraction of the wheat proteins. It is probable that all enzymes have not the same chemical structure, and possible that there may be some similarity in constitution between enzyme and the substrate on which it acts.

ON THE CLEANSING ACTION OF SOAP.

By E. Feilmann, Ph.D., B.Sc., F.I.C.

Many attempts have been made to explain the cleansing action of soap; among the most recent work in this direction was that of Spring (*Zts. f. Chem. u. Ind. d. Kolloide*, *4*, 161; *6*, 17, 109, 164), who showed conclusively that soap did not merely remove greasy matter from soiled materials, such as cellulose, but also removed finely divided solids perfectly free from fatty or oily matter, such as carefully degreased charcoal.

The cleansing action of soap still awaits a perfectly satisfactory explanation, and without entering into theoretical speculations, the writer wishes to point out certain analogies. Spring showed that a suspension of charcoal in soap solution passed through an ordinary filter paper, whilst when suspended in pure water the same charcoal was completely retained by the filter; even on reversing the filter, so that the charcoal was on the outer surface, it was not detached by washing with pure water, a fact which Spring assumes to be due to the formation of a "compound" between the paper and the charcoal, whilst it was immediately removed as a suspension, passing unchanged through the filter, on washing with soap solution.

Soap consists of the alkali salts of weak organic acids, and innumerable instances are known of the action of similar compounds on certain classes of solids with the production of fine suspensions which pass through an ordinary filter, or even of colloidal suspensoids, and there seems some reason to suppose that we are here dealing with a very general phenomenon, varying in degree according to the nature of the "disintegrating" agent and of the solid on which it acts. Thus the writer has observed that an alkaline casein solution removes considerable quantities of iron oxide from many ores and minerals in the form of a very fine suspension, which passes unchanged through a filter and only deposits on standing for a prolonged period, and Acheson uses a solution of tannic acid in dilute ammonia, *i.e.*, ammonium tannate, for producing fine suspensions of graphite, kaolin, etc., which can also be passed unchanged through a filter. Also many finely divided metals, oxides, etc., are obtained as fine suspensoids by being washed with solutions of ammonium citrate and tartrate and alkali cyanides, and the insoluble sulphide dye stuffs are dissolved to colloidal suspensoids by the action of alkali sulphide solutions. The stripping action of soap solution on many dyed fabrics, even though they may be perfectly fast to water, also reminds one strongly of Spring's experiment with the charcoal and filter paper. The production of colloidal suspensions of tungsten and other elements by Kuzel's method, that is by alternate treatment with dilute acids and alkalies, may quite possibly be due to similar causes, and so may the action of alkali caseinates, alkali silicates, etc., as protective colloids.

The use of soap as a cleansing agent in aqueous solution is of such a highly respectable antiquity, and on the whole, is so effective, that its replacement for cleansing purposes in aqueous solution on any scale by other substances may not seem very probable. At the same time, it may be pointed out that the admixture of alkali silicates and resinates with soap is a widely diffused practice, and that in certain instances the replacement of soap by the alkali salts of other weak acids, organic or inorganic, may lead to results of technical value, especially if it is found feasible to use acids which are more readily recoverable than the ordinary fat acids.

PROGRESS IN ELECTRO-CHEMISTRY.

By F. Mollwo Perkin, Ph.D., F.I.C., F.C.S.

Of late years the technology of electro-chemistry has become a most important branch of chemical industry. It took a long time after the discovery of electro-chemical processes for them to be employed on a technical scale. Instance, for example, the discovery of the elements sodium and potassium by means of galvanic electricity. That was in 1808, but it was not until the year 1890 that Castner introduced the first practical method of manufacturing sodium hydroxide. To-day the whole of the sodium of commerce, 5,000 to 6,000 tons, is produced by a modification of this method.

Naturally, to produce a substance on the laboratory scale, and ultimately to manufacture it on a large scale, is always a slow and tedious process. In the case of electro-chemical products it was, however, mainly due to the want of satisfactory machinery for obtaining the requisite electrical energy. But with the advent of the dynamo electro-chemical methods commenced to be employed technically. Even then, with an adequate supply of electricity, the difference in preparing sodium by the electrolysis of sodium hydroxide on a piece of platinum foil, and manufacturing it by the hundredweight, was an exceedingly difficult problem. The cheapening of sodium by the introduction of the electrolytic process, also as a consequence, meant the cheapening of all the other processes in which metallic sodium is employed and the employment of sodium for new purposes. Thus, for example, it meant a great reduction in the cost of manufacture of cyanides, and made it possible to employ them economically in the gold industry.

By means of the electric furnace the metal calcium was first isolated in the pure state, and it is now a comparatively cheap commercial product. It only requires greater outlets for this metal, with consequently increased production, for the price to become very much lower.

Aluminium, although not originally isolated by means of the electric current, is now entirely manufactured by electrolysis of aluminium oxide dissolved in fused cryolite. Attempts are continually being made to produce it more cheaply by employing aluminium silicate, a product which in various forms exists in enormous quantities. According to one recent patent the aluminium silicate is mixed with carbon and iron and strongly heated in an electric furnace. By this means ferro-silicon is produced and an aluminium slag, mainly aluminium oxide with a little silica and iron oxide. The slags are then pulverised and the globules of ferro-silicon separated magnetically. The ferro-silicon is employed in the ironworks and alumina for the production of metallic aluminium. The suggestion is a neat one, but we doubt if oxide of iron and silica are contained in the alumina if it will be of much value for the manufacture of aluminium. It is one of the most important points in the manufacture of aluminium that the aluminium oxide should be free from silica and iron. The product actually employed, which is made by heating bauxite under pressure with caustic soda, is of a snow-white appearance.

When one bears in mind the complicated process necessary for the purification of the materials used in the manufacture of aluminium and the great care necessary in the electrolysis of the cryolite-alumina bath, one is astonished that it can be manufactured at such a low price. Nor is this all. Aluminium is one of the most difficult metals to cast and work. The temperature must be just so, otherwise the casting will not be satisfactory. It is also well known that aluminium is a very difficult metal to cast, and that all vessels made must be riveted, spun or autogenously joined.

The difficulties of dealing with metallic aluminium for a long time prevented its coming into extended use, particularly in chemical manufacture. The Aluminium Plant and Vessel Company of Wandsworth, however, now manufacture aluminium vessels for the chemical industry of almost any size, the joints being made in such a manner that they are hardly recognisable.

Of recent years the greatest advances in electrochemistry, or rather electro-thermal chemistry, have been in metallurgy and in the fixation of atmospheric nitrogen.

In connection with electro-metallurgy special ferroalloys are now manufactured, which were practically unknown until the advent of the electric furnace. For the manufacture of special tool steels the electric furnace has passed the experimental stage. In this country steel manufacturers have been rather behindhand in experimenting with and introducing the electric furnace. Probably this is due to several causes, the inherent conservatism of the British manufacturer, the great excellence of British tool steel, and to the idea that electricity can only be satisfactorily employed when cheap water power is obtainable. In the first place conservatism in business no longer pays. To-day you may be the best in a certain line, to-morrow someone else may have a better product in a similar line, which will beat you out of the field. In the manufacture of special steels the employment of water-power is not an absolute necessity; after all it is only in some places that it can be obtained cheaper than gas or coal energy. In many places electro-chemical processes are being run most successfully where water-power is not obtainable.

In blast furnace operations special difficulties have been met with in introducing the electric furnace. These difficulties are gradually being overcome, and successful work has been carried out in Norway in this connection. One of the most difficult problems now being attacked is the winning of zinc from its ores by means of the electric furnace. Here there is plenty of scope for the employment of electrical energy, as the ordinary processes are among the least satisfactory of metallurgical operations. From the experimental plant already in operation it seems probable that the technical difficulties involved will shortly be overcome.

AGRICULTURAL CHEMISTRY.

THE FUNCTIONS OF LIME IN THE SOIL.

By C. T. GIMINGHAM, F.I.C.

(University of Bristol.)

SINCE very early times it has been recognised that the presence or absence of a certain proportion of lime in the soil has a very important bearing on fertility; and modern lines of investigation have shown that it is almost impossible to exaggerate this view. This is not due to any special value of lime as a plant food, since all soils contain sufficient calcium for the needs of the plant, but, as a base, it exerts an influence on the soil in many directions.

There are a number of processes at work in the soil tending towards the production of acid, which, if unchecked, will bring about a condition of infertility to which lime or calcium carbonate is the natural corrective. In the last few years attention has been closely directed to questions connected with the soil reaction, especially from the biochemical point of view. The growth of the higher plants is dependent to a very large extent upon the nature of the microflora of the soil, and this, in its turn, depends almost entirely upon the reaction of the soil moisture. The bacterial processes of nitrification, nitrogen-fixation and, according to some workers, ammonia-formation, all require the presence of lime. In districts of high rainfall, the formation of humus in the soil is also favoured by abundance of lime; though, where the rainfall is low, oxidation is often increased to such an extent that the building up of humus comes to a stop. Excessively large applications of lime may, indeed, sometimes be injurious, and it has recently been recorded by Fleischer and Hess that in this way harm has been done on some of the acid moor soils in Germany (Hochmoor), which was accompanied by appreciable loss of nitrogen.

It is very frequently necessary to ascertain whether a soil needs or will benefit by the addition of lime, and the methods available for this purpose are not all that can be desired. It is easy to classify, on the one hand, soils which on treatment with hydrochloric acid show a vigorous effervescence, and on the other, those which give an obviously acid reaction; but a great number of soils are neutral and lie between these two extremes. The determination of minute amounts of carbonate is not altogether satisfactory, particularly in the presence of much organic matter. Further, a great many factors—physical, chemical and biological—have to be taken into account in the interpretation of the result, and a percentage of lime sufficient to maintain the fertility of one type of soil may be quite insufficient in another.

In this connection an interesting biological method has recently been suggested, which may prove of assistance in attempting to determine the "lime-need" of a soil. Use is made of the sensitiveness towards an acid reaction displayed by a nitrogen-fixing soil bacterium, called *Azotobacter chroococcum*, which can be easily obtained in pure culture, and which forms an easily recognisable growth on the surface of a liquid culture. This organism grows well in a 2% mannite solution containing 0·02% potassium phosphate. A small quantity of the soil to be tested is added to 50 cc. of such a solution, which is then inoculated with a strong growing pure culture of Azotobacter, and kept at a temperature of 27°—30°C. for a few days: absence of any growth of the organism will indicate a lack of lime in the soil.

Christensen and Larsen (*Centrlb. Bakt.*, etc., *II.*, *Bd.* 29, 1911) have compared this method with others, and believe it to be of considerable value, though probably a positive result cannot by itself be taken as conclusive evidence that the soil would not benefit by an application of lime. In conjunction with a test of the reaction of the soil towards litmus the method gives useful information. The results obtained could not, however, be correlated with those given by a determination of the amount of lime soluble in an ammonium chloride solution (Meyer's method).

In addition to preventing any harmful accumulation of acid, lime has an important influence on the physical condition of the soil by its flocculating action on the finest clay particles; larger aggregates are formed and the soil is rendered more porous and consequently better aërated. In a heavy clay soil this is of the greatest importance, and the percentage of calcium carbonate is one of the chief outside factors to be taken into account in the interpretation of a mechanical analysis. One or two per cent. may greatly change the characteristic properties of the clay fraction. Hall and Russell, in their Paper on "Soil Surveys and Soil Analyses" (*J. Agric. Sci.*, Vol. IV., p. 182, 1911), mention two such cases. Soils of quite similar mechanical composition, but differing in their content of calcium carbonate, were entirely dissimilar in physical condition, a lack of lime causing the one to be heavy and sticky and unfit for arable cultivation, whilst the other was comparatively easy to work. In very calcareous soils the chalk may become the dominating factor to such an extent as to make a mechanical analysis of small value.

PHOTO CHEMISTRY.

By C. E. Kenneth Mees, D.Sc.

ABSORPTION PHOTOMETRY.

(*Continued.*)

Spectrophotometers of different types differ chiefly in the methods used for diminishing the intensity of the variable beam, and in the device for bringing the fields into contact. In the oldest spectrophotometer, used by Vierordt in his classic researches, the slit was divided into two portions, of which the opening could be independently varied, and an absorbing substance being placed in front of the lower half of the slit, the upper half was closed until equality of the fields was obtained. Later and more accurate instruments have chiefly been of the polarizing type: the two instruments principally used at present being the Huefner spectrophotometer and the Martens-Koenig spectrophotometer. In the Huefner instrument, which is made in its original form by Albrecht of Tuebingen, and, with a wave-length spectroscope, by Adam Hilger, Ltd., the lower beam, before entering the slit, passes through a polarizing Nicol, the upper beam traversing the solution to be measured. Immediately in front of the slit is a rhomb of glass, known as the Albrecht rhomb, which inverts both beams separately and brings them to juxtaposition in the eye-piece of the instrument. After dispersion, the two beams travel through an analysing Nicol, mounted on a divided circle, and by turning this Nicol the lower unabsorbed beam can be brought to equality with the upper. The intensity of the lower beam is, of course, $\text{Cos}^2\,\theta$ where θ is the angle through which the analyser has been turned, and the extinction co-efficient is therefore $-\log \text{Cos}^2\,\theta$. In the focal plane of the eye-piece are placed two small shutters by which any spectral region can be isolated, and the wave length of the region isolated is read on the wave-length scale. The solutions are held in a glass cell containing a block of glass which nearly fills the lower half of the cell, the cell having an internal thickness of 11 m.m. and the glass a thickness of 10 m.m., so that the difference of absorption in the upper and lower beams, due to 10 m.m. of solution, is measured. In the Koenig instrument both beams are polarised, and the analysing device is a Wollaston prism, by which the two beams are brought to equality as in the Huefner instrument. But instead of the Albrecht rhomb, Martens uses a bi-prism.

There are certain differences in the use of the two instruments. It is frequently advantageous to be able to actually see the spectrum, as is the case with the Huefner instrument, and there is also far less loss of light in the Huefner and much less scattered light, so that readings can be made up to considerably higher extinctions. But, on the other hand, the short dividing line, when narrow spectral regions are used, limits the accuracy of the Huefner instrument, and for the most accurate possible measurements of medium absorptions, the Koenig instrument has advantages.

In the spectrophotometry of solutions there is considerable difficulty, especially in the blue and violet end of the spectrum, owing to the light scattered in the instrument from other portions of the spectrum almost completely transmitted by the solutions. For instance, suppose that it is required to measure the extinction co-efficient at W.L. 4800 of a solution of chromic acid; the amount of light transmitted at this wave length may be perhaps $\frac{1}{100}$ of the incident light, but at 5500 the absorption is practically nil, and the chromic acid is therefore transmitting into the spectroscope yellow light of at least a thousand times the intensity which is being measured, and the scattering of this light in the spectroscope causes very serious difficulty in making accurate measurements. This difficulty may, however, easily be removed by the use of what may be termed compensating filters, to remove from the light, before it enters the spectroscope, as much as possible of the portions of the spectrum which are not being measured. A blue filter, for instance, placed in the path of the light, will make the measurement of the chromic acid at 4800 perfectly easy.

Since the extinction co-efficient for a given wave-length is proportional to the concentration of the solution, it is clear that the spectrophotometer can be used for much technical work involving coloured solutions, in place of any other analytical method. Suppose, for instance, it is desired to know the concentration of eosin in a commercial sample of dye. A standard solution is made up, and its extinction co-efficient measured at, say W.L. 5200, at the same time the extinction co-efficient of a standard sample of pure eosin being measured. The percentage of eosin in the sample can be immediately calculated from the ratio of the two extinction co-efficients. If the eosin be adulterated with another red dye, an examination of the absorption spectrum will almost certainly show this, and probably enable the dye to be identified, when comparison with a pure sample of the adulterant will allow the percentage both of eosin and adulterant to be separately determined.

I hope, at a later date, to deal with the use of photometers in photographic work, and especially with some of the simplified photometers employing black wedges, which are now being introduced.

Nomenclature of Alloys.—Dr. Rosenhain has pointed out before the Institute of Metals, the difficulty which arises from the present state of affairs in this direction, and it was proposed that the Institute should appoint a committee to deal with this matter. There seems to be general confusion beween manganese bronze and manganese brass, from metal and naval brass. Sir Gerard Muntz supported the suggestion owing to the difficulties experienced in the non-ferrous metal trades. The Institute will certainly be doing good work if it succeeds in devising a systematic nomenclature which can replace the present unsatisfactory condition of affairs.

Volatisation of Metals *in Vacuo*.—Prof. Turner has extended the work which has been done in this direction, with very interesting results; even suggesting a method of refining copper by this method. In this way zinc can be entirely separated from copper. The point is one which is also of importance in the production of high vacuo lamps, even platinum volatising under these conditions. This new method of refining metals has possibilities of commercial application.

Testing Building Materials.—A sand blast used under constant conditions and a pressure of two atmospheres has been used at the Gross Lichterfelde Institute for testing the resistance to wear of granite, wood, and other materials used in building construction, and road building.

UNIVERSITIES AND COLLEGES.

THE LEATHERSELLERS' COMPANY'S TECHNICAL COLLEGE, BERMONDSEY.

By M. C. LAMB, F.C.S., Director of The Light Leather Department.

Historical.

LIKE most big institutions, the Leathersellers' College did not attain to its present size and importance immediately, but is the product of gradual advancement and progress. In 1894 the establishment of some technical classes in connection with the leather industries was suggested, and this immediately met with the approval of the Court of the Leathersellers' Company. The scheme was commenced with an experimental course of lectures given by Mr. S. Lavington Evans, at Herold's Institute, during the winter of 1894-5. These lectures proved a great success and encouraged the Company to make a grant of money for the equipment and maintenance of a permanent school for leather manufacture. The London County Council also made a grant, and the management of Herold's Institute became vested in the Governors of the Borough Polytechnic, who secured the services of Dr. J. G. Parker as Director, and who, during the session of 1895-6, gave a course of evening instruction. The success attending these classes warranted an extension of the work, and in 1896 day classes were commenced. In 1898 a Leather Dyeing and Finishing Department was added. The work of the Institute had now become more onerous, and the staff was increased; the management was invested in a committee, consisting of members of the Leathersellers' Company, the Borough Polytechnic, the London County Council and the Herold's Trustees. In 1899 the writer was appointed Director of the Dyeing and Finishing Department, and in the same year a small experimental tannery was installed. The work at Herold's Institute gradually progressed and strained the resources of the accommodation available, until it was realised that the Institute was not nearly adequate to enable a thorough practical and technical training being given, handicapped as it was by its position and the want of space. So it was that after the old Herold's Institute had been in existence for fifteen years, during which period some 2,000 evening students and 250 day students had passed through the full course of technical instruction, the Leathersellers'

GENERAL LABORATORY.

LIME YARD FOR HIDES.

Company decided to build and equip a new Technical College, fitted with every modern appliance, and replete in all respects to enable it to meet any demands which might be made upon it from all sections of the leather industries.

The final plans having been made and passed, building operations were commenced in 1908, and the new buildings were opened by the Right Hon. The Lord Mayor of London, in October, 1909.

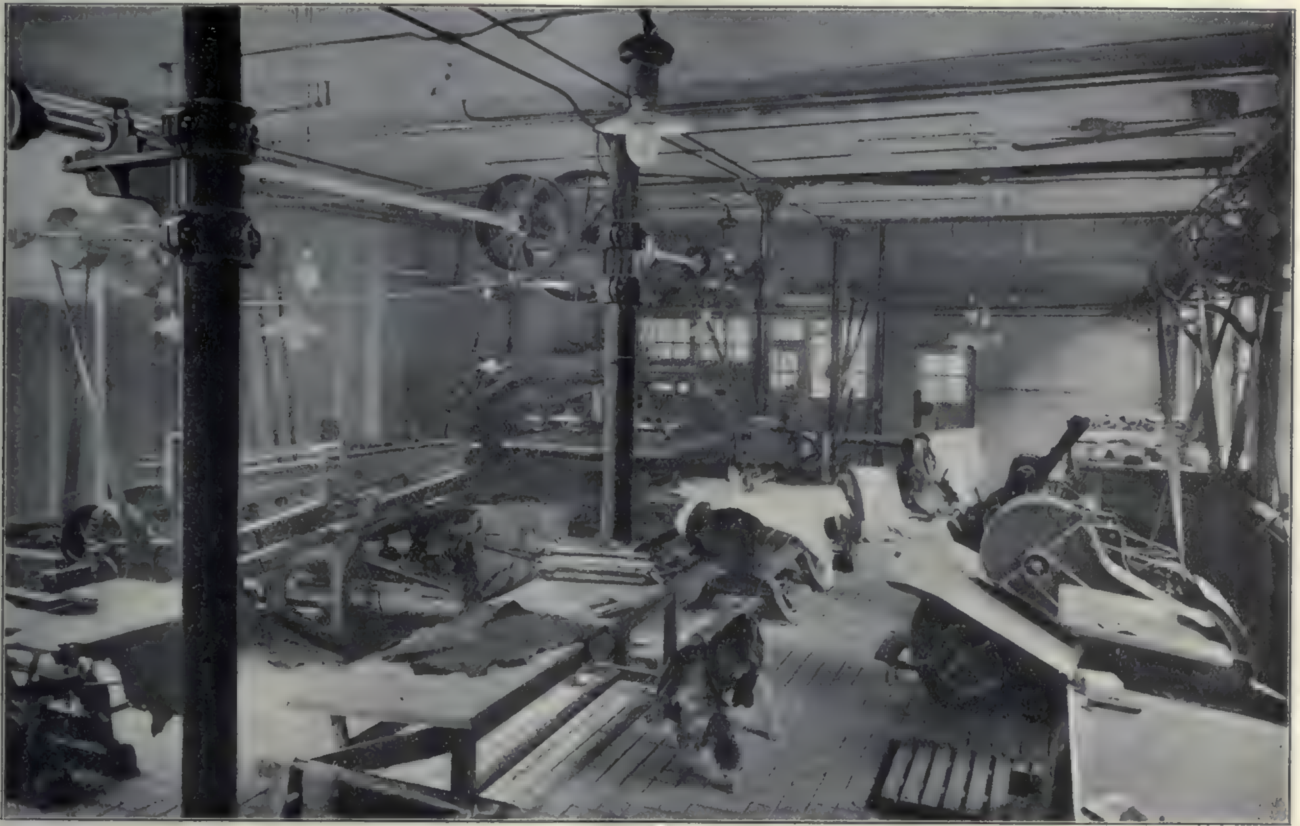
Equipment.

The College is equipped with the necessary plant and machinery for the purpose of instruction in every branch of leather manufacture. On the ground floor are situated two large experimental tanneries—the heavy leather tannery, consisting of a model lime-yard and tannery, capable of dealing with twenty-five hides per week intended for sole, harness, belting and dressing leather; a light leather tan-house, with equipment for treating twenty thirty dozens of sheep, goat or calf skins for every variety of finished leather, from glove leather to boot upper leather. The dye-house, adjoining the tan-house, is fitted with dye-trays, paddles and drums, to deal with the dyeing and finishing of the product of the tanneries, and also for the redressing of foreign tanned skins. Adjoining the dye-house is the machine-room containing all the necessary machines for the scouring, glazing, shaving, buffing, rolling, staking, fluffing, and currying of any kind of leather. There is also a small currier's shop, fitted up with the requirements for currying, both by hand and by drum stuffing.

A CORNER OF THE LABORATORY.

LIGHT LEATHER TANNERY.

On the second floor two large drying rooms have been erected for the drying and stoving of the finished leather; these rooms are fitted with a patent appliance for driving in either hot or damp air, and the temperature of the room and the hygrometric condition of the atmosphere can be regulated to any desired extent. In addition to the foregoing plant there is also a water-softening plant, by means of which the water used in the various processes is softened. The Thames water (with which the College is directly connected) is also rendered fit for many of the tannery purposes. The equipment also includes a general students' laboratory, capable of accommodating forty students, and in which electric power has also been installed. Adjoining the main laboratory is a balance room and a fume room.


FINISHING SHOP.

On the first floor are research laboratories for the use of advanced students, where difficulties which arise in the processes connected with the industry are investigated and where new processes and original researches are carried out; a bacteriological laboratory and a special room for microscopy and microphotographic work; a museum, containing samples of materials from all parts of the world used in the manufacture of leather, and leather and skins showing the imperfections due to faulty manipulation either in the tanning or the processes connected with it; and defects brought about by peculiar growth, breeding or other causes. A well-stocked library, comprising a complete set of reference books in chemistry, chemical technology and leather manufacture, also all the trade papers and periodicals published in connection with leather manufacture throughout the world, has been provided. The museum and library are open to members of the trade, and it is used as a place of reference. A large lecture theatre, with accommodation for 100 students, is fitted with an experimental lecture table and a new electroscope projector, by means of which it is possible to project on to the screen a view of a specimen of leather or book illustration without the necessity of photographic reproduction.

The whole space occupied by the buildings is some 40,000 square feet, and it can safely be said that the College is not only the largest and best equipped of its kind in the world, but that it may be regarded as a model technical school for many other branches of industrial chemistry.

Curriculum.

The courses of study in the day classes are arranged to meet the requirements of each individual student, and students are thus trained to take almost any position in the leather trade.

Students for the day division come from all parts of the world, and almost all civilised countries have sent students at some time or other. The majority of these students are trained for positions of responsibility, such as managers, chemists specialising in the industry, or departmental heads.

In the evening division the students are largely drawn from leather works and tanneries in the neighbourhood, and are practically engaged in the actual manufacture of leather. These students either desire to understand the *rationale* and scientific principles on which leather manufacture rests, or to perfect themselves in some particular branch of the industry.

Dye House.

The College is divided into two departments, (*a*) Heavy Leather Tanning, and (*b*) Light Leather Manufacture.

The usual course of instruction extends over two years, but a short one year's course is arranged for those who have already some knowledge of the subject; and students are also admitted, by special arrangement, for short periods of instruction in some special branch of the industry in which they are particularly interested. Students who take the two years' course, study heavy leather manufacture in the first year, and in the following year light leather manufacture, or *vice-versâ*. Those students who have sufficient time at their disposal take a three years' course; in this case the greater part of their time in the third year is devoted to carrying out original research or the investigation of practical problems of an advanced nature.

The student spends each morning in the practical tan-yards and dye-houses, and each afternoon in the chemical laboratories. The practical work in the manufacture of all kinds of leather, sole, harness, belting, dressing, sheep skins for all purposes, goat skins for upholstery and chrome, calf skins, pigskins, chamois leather, etc., etc., is carried out from the raw state to the finished warehouse by the students themselves, and the scheme of work is arranged not only to give practical instruction in the tanning and finishing of the various leathers, but to impart the necessary underlying principles: the chemistry and physics of tanning and dyeing. During the practical work, samples of the liquors, leather, materials used in the manufacture, are taken and analysed by the student, so that he is taught the method of chemical control of all the processes of manufacture. Lectures are given on all branches of the industry; the methods of manufacture of different classes of leather; practical microscopy and bacteriology of leather manufacture.

The Entrance Hall.

Present Position of Electro-Analysis.

By Henry J. S. Sand, Ph.D., D.Sc.

The progress made in Electro-analysis during the past year or two has followed closely on the lines which have been opening up and developing during the last ten years. A brief survey of the principal advances made during the latter period must therefore precede accounts of more recent work.

The reduction in the time required for the deposition of a metal from a minimum of two or three hours to about five minutes, by the use of very high current-densities, accompanied by vigorous stirring of the electrolyte, is undoubtedly the most striking development that has taken place. Circulation of the electrolyte has for long been very generally applied in technical processes, and as early as 1880, v. Klobukow (*Journ. Prakt. Chem. 33*, 473) described a form of apparatus for electro-analysis, in which the electrolyte was stirred by a rotating cathode. The results were described as most astonishing, but apparently no very high current-densities were employed, and the revolutionary nature of the practical results obtainable remained unrecognised.

As regards the theoretical aspect of the matter the fact has probably always been appreciated by analysts and other electro-chemists, that it is only in the layer in immediate contact with the electrode that electro-chemical processes take place, but it was not properly recognised that, apart from convection currents produced by stirring in one form or another, it is only the exceedingly slow process of diffusion which can neutralise the depletion caused by electrolysis; in fact, the erroneous notion was frequently held that electrical transference of ions may in itself sometimes be effective for this purpose.

The mathematical theory of the concentrated changes which occur in an electrolyte, in which no convection-currents take place and through which an electric current of constant strength is passed, was first developed by H. F. Weber in 1879 (*Wied. Ann. J.*, 536), for the case of a thin layer; for the case of a layer of infinite thickness which approximates closely to many cases occurring, practically the theory was elaborated by Sand in 1900 (*Phil. Mag.*, 61, *1*, 45, and *Zeit. Phys. Chem. 35*, 641), for similar conditions, but with an alternating current, it was developed in 1899 by Warburg (*Wied. Ann.*, *67*, 493).

A theory which approximates fairly closely to what takes place in a vigorously stirred solution, the theory of a diffusion-layer, was put forward by Nernst and Brunner in 1904 (*Zeit. Phys. Chem.*, *17*, 52—102). This was an extension of work by Noyes and Whitney on rates of solution (*Zeit. Phys. Chem.*, 1897, *23*, 689).

Quite recently the theory of concentration-changes has again been taken up and treated in a very general manner in America by T. R. Rosebrugh and W. Lash Miller (*Journ. Phys. Chem.*, 1911, *14*, 816). The lack of efficiency of diffusion alone in neutralising changes of concentration, produced by electrolysis with high current-densities, and the great effect produced by stirring, was illustrated by Sand in 1900, in connection with his theoretical studies, by an experiment in which an acid solution of copper-sulphate was electrolysed.

In this experiment 60% of the current was expended at the cathode in generating hydrogen when the stirrer was at rest, but on starting the latter it was replaced entirely by copper. The recognition of the fact that the influence of high current-densities can be largely neutralised by vigorous stirring, might lead to the belief that metal-deposits are not affected by current-density as such. This, however, would be erroneous. Recent work, particularly by Foerster and his pupils, Leblanc and his pupils, and by Sand and Black, shows that independently of concentration-changes in the electrolyte, the deposition-potential of metals, and therefore also the nature of the deposit, is affected by current-density as such.

The first announcements of the striking nature of the results obtainable in electro-analysis by vigorous stirring of the solution combined with high current-densities were made in America in 1903, almost simultaneously by Gooch and Medway (*Amer. Jour. Science* (4), *15*, 920) on the one hand, and Exner, working in Edgar F. Smith's laboratory, on the other (*Journ. Amer. Chem. Soc.*, *25*, 896).

It seems not improbable that the circumstance that small electric motors were becoming more generally available for laboratory purposes may have contributed to these discoveries, for we find that about the same time several other workers were engaged on similar lines.

Thus F. Mollwo Perkin independently described arrangements for the use of a rotating cathode (*Electrochemist*, *3*, 26, and *Journ. Soc. Chem. Ind.*, 1903, p. 1064), and Amberg was employing a rotating anode in Classen's laboratory (*Zeit. Elektrochem.*, 1904, *10*, 385 and 853).

A somewhat lengthy discussion regarding the priority of the discovery in the columns of the *Zeitschrift für Elektrochemie* was the result. Numerous workers have subsequently contributed to the development of methods and forms of apparatus for electro-analysis. A full discussion of the merits of the various forms of apparatus would be beyond the scope of this article.

Efficiency of stirring and consequent rapidity of electro-deposition, ease of manipulation, and finally smallness of cost, are the main points to which attention would have to be paid in any criticism.

As regards the various principles which have been employed, we have to consider, first, apparatus in which the electrolyte is stirred mechanically. A subdivision here arises according as the anode, the cathode or an independent stirrer is rotated. To the first class belongs the apparatus used by Exner and other workers in Edgar Smith's laboratory, and also by Fischer and Boddaert, working at Aachen (*Zeit. Elektrochem.*, 1904, *10*, 945).

It consists of a dish used as cathode and a wire spiral or bucket employed as anode. The apparatus devised by Sand (*Trans. Chem. Soc.*, 1907, *91*, 373, and 1908, *83*, 1572, *Trans. Faraday Soc.*, 1905, p. 159) in which both the anode and cathode are constructed of gauze, belongs to the same class.

(*To be continued.*)

THE PHYSICS AND CHEMISTRY OF COLLOIDS

By Emil Hatschek.

CHAPTER I.—(*Continued.*)

The simplest way to use one is to fill it with the liquid to be dialysed, and then to place it in a small Erlenmeyer flask filled with water, which is changed as occasion requires. (Fig. 2.)

In all cases the dialysis may be considered complete when the outside water remains pure—which may, of course, be tested by suitable reactions or conductivity measurements. Whatever residue is then left in the dialyser is in colloidal solution.

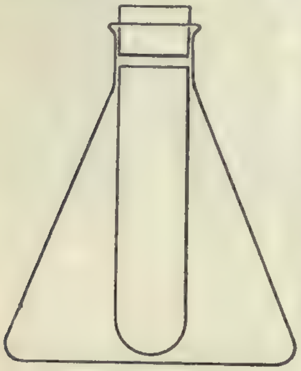


Fig. 2.

As regards the second query, exact instructions for preparing a number of sols—all of them typical—are given in the following. To avoid failures it is absolutely essential to observe scrupulous cleanliness. The water should be freshly distilled, if necessary re-distilled with a hard glass condenser. All vessels used should be of Jena glass, preferably new, but in any event cleaned with nitric or chromic acid.

Gold solutions.—Four cc. of the commercial 1% gold chloride solution is diluted with 100 cc. of distilled water. A solution of 2 gr. of tannin—the "tannic acid, pure" of commerce—in 100 cc. of water is then made up. If one part of the dilute gold chloride solution is mixed with three parts of the tannin solution, a blue gold sol results; if equal parts are taken, the resulting gold sol is ruby red. In both cases the reaction takes about a minute to complete itself. These sols are very stable and can be kept for some time: as they contain tannin in excess they are, however, like pure tannin solutions, liable to go mouldy.

A great range of, much less stable, sols can be obtained by using instead of tannin one of the photographic developing agents as reducer, *e.g.*, hydrokinone, or pyrogallol, about one part in 500 of water. The latter occasionally gives a fine sol, blue in transmitted and brick-red in reflected light.

Silver solutions.—These are much less stable, but one fairly satisfactory in this respect may be prepared in the following way:—To 5 cc. of a one per cent. silver nitrate add, drop by drop, ammonia, until the precipitate just disappears, and then dilute with 100 cc. of water. If equal volumes of this solution and of the tannin solution just described are mixed, a silver sol results, which is clear and brown in transmitted light, but often shows a greenish colour in reflected light, resembling certain petroleums.

Antimony trisulphide solution.—Dissolve two grammes of potassium-antimony tartrate ("tartar emetic") in 100 cc. of water. Make a dilute ammonium sulphide solution—about one part of the "strong" sulphide to 25 parts of water, and mix equal volumes of the two solutions. The colour gradually changes to yellow or orange. This sol, like the preceding ones, may then be purified by dialysis.

Arsen trisulphide solution.—Boil 2 grammes of arsenious acid (white arsenic) for a few minutes with 150 cc. of water, then filter and allow to cool. If hydrogen sulphide is then passed through the cold solution, it gradually turns orange, with a strong greenish surface colour in reflected light.

Ferric hydroxide solution.—This sol is very easily obtained in the following manner: heat about 500 cc. of water to boiling in a beaker or Erlenmeyer flask. While it is boiling add about 5 cc. of a 33% solution of ferric chloride (which has been filtered, if necessary). The colour at once changes to a beautiful brownish-red, the sol being perfectly clear and very stable. It can be kept for weeks without any special precautions, but may be dialysed to remove the free hydrochloric acid formed by the dissociation.

These sols have been selected as being very easy to prepare and as showing all the typical qualities of colloidal solutions. Two of these may very easily be studied: the appearance with "Tyndall" illumination and the behaviour towards electrolytes. To show the former, the sol is placed in a glass vessel with plane parallel sides, and a strong beam of light—the light of a small arc or a Nernst lamp concentrated by a lens does very well—projected through the liquid. This, if looked at from the side against a dark background, will appear turbid, with a greenish sheen in the case of the gold and silver sol.

As regards the behaviour of the sols towards electrolytes, it is only necessary to add a few drops of any salt solution—preferably barium or calcium chloride in the case of the metal and sulphide sols, and sodium sulphate for the ferric hydroxide—sol to see a marked change at once. The solutions become turbid, change colour, and after some time the dissolved substance will be found to have settled out. This may take some hours with the gold and silver sols, but if the sodium sulphate is added to the ferric hydroxide sol while the solution is still hot, the ferric hydroxide will come down as a flocculent mass in a few minutes.

CHAPTER II.

In the preceding chapter some general characteristics of colloidal solutions, such as their appearance with suitable illumination and their behaviour on the addition of electrolytes, have been referred to, and one method of investigating them —dialysis—has been described in some detail. It now remains to describe the other methods applied to the study of colloids in more recent times, and to see what conclusions as to the nature of the colloidal state, or in other words the difference between true and colloidal solutions, can be drawn from the results obtained by these various methods.

As regards dialysis, it must be added that parchment paper is by no means the only suitable membrane for this purpose. Collodion membranes—left by the evaporation of a solution of nitro-cellulose in ether-alcohol —and fish-bladder are used extensively, especially in physiological work. The effect, however, is always the same: all these septa permit the passage of true solutions, *i.e.*, of liquids in which the dissolved substance is present in a state of molecular or even smaller division, while they retain colloids. If we ask ourselves for the reason of this phenomenon, the simplest answer is obviously that the colloids are present as particles or aggregates too large to pass through the pores in the membranes. They may of course actually have molecules of this size: a dye-stuff, Congo Red, *e.g.*, which lies on the border between true and colloidal solutions, contains 72 atoms, and has a molecular weight of 654, and bodies like the albumins no doubt have molecules of still more considerable size. On the other hand, this explanation is hardly applicable to inorganic sols, especially metal sols, and it is necessary to suppose that these contain aggregates formed of a very large number of molecules.

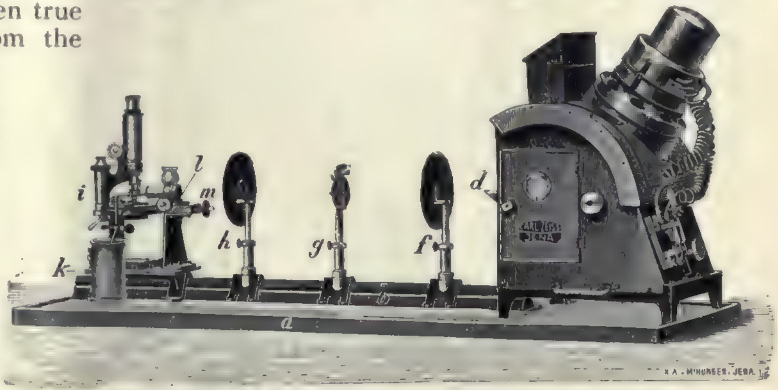


Fig. 3.—General Arrangement of the Slit Ultra-Microscope

It is, however, impossible to draw any conclusions as to absolute size from the process of dialysis, in view of its being carried out without any pressure. It is quite easy to retain particles by ordinary filtration without much pressure, which are very much smaller than the pores in the filtering material: bacteria, *e.g.*, are retained by sand filters, although they are very much smaller than the interstices between the sand grains. To eliminate this difficulty, various investigators have attempted to retain colloids by filtration under pressure through very dense media, such as the filter candles used in bacteriological work. Amongst the earliest experiments are those by Linder and Picton with arsenious sulphide sols. These varied according to the method of preparation: most of them passed through the filter unaltered, but a portion of the sulphide from certain sols was retained. For these isolated cases a limit value of the size of the particles could thus be obtained.

Much more extensive data can be gathered by the aid of a method for separating colloids invented by H. Bechhold, and called by him, in allusion to the ultra-microscope, "Ultra-Filtration." Membranes similar in nature to those used in dialysis are employed, but these are not immersed in the solvent, and considerable pressure is used. To permit of the latter, the membranes are prepared in the following manner: strong hard filter paper is impregnated, generally in vacuo, with either a gelatine solution or acetic acid collodion of known strength. The gelatine filters are then rendered insoluble by immersion in cold formaldehyde for several days, while the collodion filters are immersed in water, which gradually dissolves the acetic acid and leaves a gelatinous mass of nitro-cellulose in the substance of the paper. The filters are clamped in a small pressure vessel and are supported on wire gauze and perforated metal, so that pressures up to ten atmospheres can be used. A very important feature, predicted and subsequently verified by Bechhold, is the ease with which the porosity of these ultra-filters can be varied by altering the strength of the original gelatine or collodion, so that colloids which passed freely through a "2½%" collodion filter, *i.e.*, one made from a collodion containing 2½% of nitro-cellulose, could be entirely retained by one made from 5% collodion.

The size of the pores in these filters can be determined by two methods proposed by Bechhold and by a third one suggested by the author and also tried by Bechhold. They are all based on various properties of capillaries and need not be discussed here in detail. According to the concentration of the collodion or gelatine the diameters of the pores lie between 930 $\mu\mu$ and 21 $\mu\mu$. (The $\mu\mu$, which is the unit generally employed in giving the dimensions of such particles as we shall have to deal with, is $0{\cdot}001\,\mu$, while the μ, which is generally employed in ordinary microscopic measurements, is 0·001 mm. The $\mu\mu$ is therefore one millionth millimetre.) These dimensions give us limits for the sizes of the particles retained by such filters: if the particles are retained, they are probably, though not necessarily, larger than the pores; if they pass through the filter, it is reasonably certain that they are much smaller than the pores.

Evidence tending in the same direction and towards the same limits is afforded by an optical property of the sols to which reference has already been made: their turbid appearance in the Tyndall cone. If such a cone is produced, *e.g.*, in a gold sol, it appears greenish, and if this greenish reflected light is examined by a suitably placed analyser, it is found to be polarized. It may be worth mentioning that herein lies its difference from true fluorescence: the blue light, which under similar conditions appears in a solution of quinine sulphate, is not polarised. The whole phenomenon has been mathematically investigated by Lord Rayleigh, and it has been proved that, to produce it, the particles reflecting the light must be small compared with the wave length of light. The values of the latter are of course known accurately and lie between 450 and 760 μμ for the visible spectrum. These limits again agree very well with those deduced from the experiments with ultra-filters.

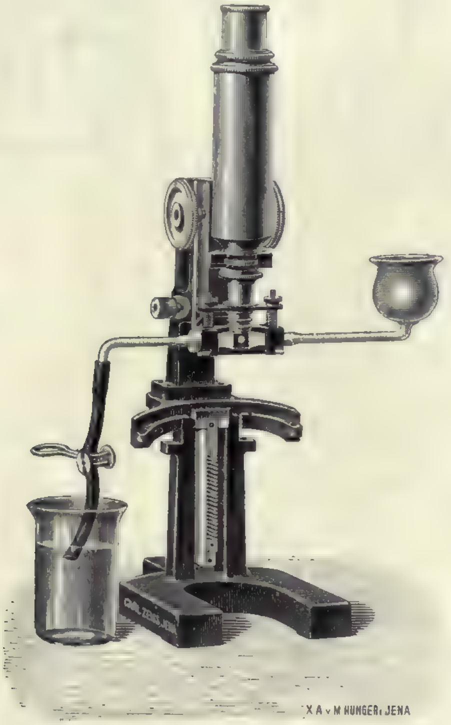


Fig. 4.—Microscope with Quartz Chamber for Ultra-Microscopic Examination of Liquids.

At the same time they answer a question which may already have occurred to the reader: why the size of such particles as may be present in a sol cannot be determined directly by microscopic observation and measurement? The answer is that particles, which are small in comparison with the wave length of light, are invisible in the ordinary microscope. It was shown by Abbe in his classical investigations on the microscope that the lower limit of visibility varied from 0·8 to 0·4 μ, *i.e.*, 800 to 400 μμ. As a matter of experience, all sols which appear clear to the eye, and many which appear distinctly turbid, entirely fail to show any particles with the ordinary methods of illumination.

It has, however, been known for some time that with favourably arranged illumination objects of sub-microscopic dimensions could be rendered visible. Thus it had been shown by Fizeau and Ambronn that slits of much smaller width than the lower limit of visibility could be seen if they were strongly illuminated in a dark field. This observation suggested to Zsigmondy and Siedentopf the possibility of rendering visible the individual particles which collectively produce the Tyndall phenomenon, if only the light reflected or dispersed by the particles was permitted to enter the instrument and no direct rays from the source of light.

This expectation has been brilliantly realised and the "Ultra-microscope"—as the microscope fitted with this peculiar form of illumination has been called—has now become an indispensable instrument of research. The principle of it is very simple: a powerful beam of light is thrown horizontally through a small body of the liquid, which is observed through a microscope, the axis of which is vertical. It is at once obvious that no light can enter the instrument, except such as has been reflected or dispersed by particles present in, and optically different from, the liquid itself, *i.e.*, they must either be opaque or possess a refractive index different from that of the latter.

The details of the actual arrangement, which have called for the exercise of very great ingenuity, are shown in Fig. 3. The light of the arc lamp *d* is projected by the lens *f* on a "precision" slit *g*, the width and height of which can be adjusted very accurately. An image of the slit is formed by the second lens *h* and projected on the illuminating device proper, *l*, which is substantially a microscopic objective. This throws a narrow and intense beam of light through a cell containing the liquid, which is seen more distinctly in Fig. 4. It is of rectangular section and has two windows—the one in front admits the beam of light, while the second one is at the top and opposite the objective of the microscope. The cell is provided with a funnel at one end, and an outlet at the other, so that a large volume of liquid can be passed through the cell and examined in one setting.

As already explained, no light enters the microscope except such as is reflected from particles in the liquid, and the image formed bears no relation to the actual size of the former, but depends on the intensity of the illumination and the qualities of the microscope only. Direct measurement of the particles is therefore still impossible, but indirectly the diameters may, with certain assumptions, be determined by calculation in the following manner: The width and depth of the illuminated prism of liquid is measured by means of an eye piece micrometer, and the number of particles in the volume thus determined is counted. If the content of the sol—say the amount of gold in a gold sol—is known, the weight of gold in the illuminated volume is also known, and from this and the number of particles the weight of a particle can be calculated. Assuming the particles to be a simple geometric shape—say spherical or cubical—and their density to be that of solid gold, the diameter or edge can again be easily calculated.

(*To be continued.*)

CHEMICAL ENGINEERING.

THE CASTING OF CONTINUOUS METAL SHEETS AND RIBBONS.

By E. Halford Strange, M.Sc.

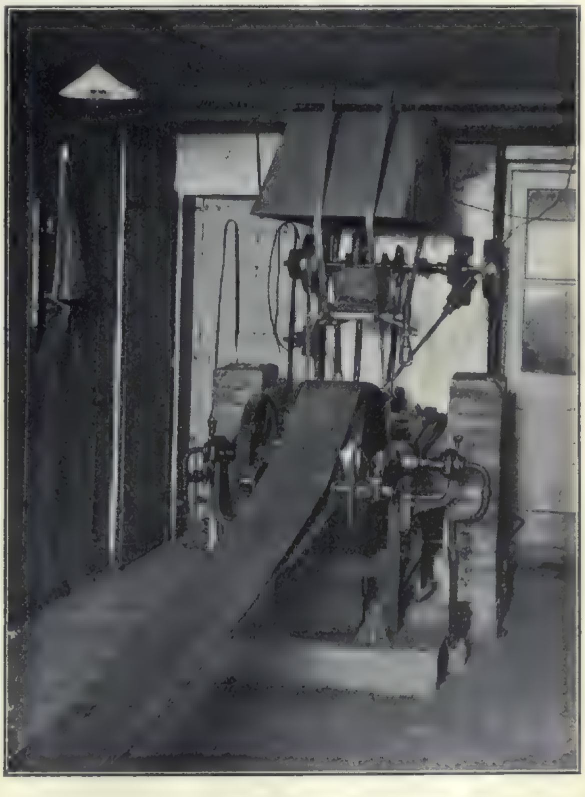
A process for the casting of continuous sheets and ribbons of metal has been under development in London for two years. The progress made during the last twelve months towards perfection is so considerable that it calls for special notice. The unexpected ramifications of a manufacturing process originally designed for a single purpose are always interesting; in the case of the process under discussion these ramifications have proved to be far greater than the inventor imagined.

The Syndicate, which has been dealing with the invention, took it over from the owners of the patents, Messrs. Strange & Graham, in order to carry out further experiments, and to place the invention on a commercial basis. The object in view was to simplify and quicken the manufacture of white lead by increasing the surface of metal to be acted upon, and at the same time to retain the cast condition of the metal, a cut or worked surface being unacted upon by the required corroding gases.

Preparing Metal Ribbon.

In the first experiment use was made of a small drum by using a tobacco tin, which was filled with water and arranged so as to revolve at a high speed. Molten lead was allowed to fall upon the surface of this primitive drum, and found that the lead was flung off in leaves, which were very thin and consequently offered a large surface for chemical action. With the assistance of others this invention was developed so that a continuous ribbon could be produced by a regular feed of molten metal to a cooled rotating drum. At this stage Mr. Graham's attention was given to other work, and he did nothing more to improve the process up to the time of his untimely death in 1905.

For several years the idea in this stage lay dormant. It was then found that in addition to making lead ribbon, ribbons of other metals, such as gold, silver, copper, aluminium, zinc, and many kinds of alloys, could be made. It was a short step from this stage to the application of these metal ribbons to many industries, such as the lead to pipe joint caulking, and the application of the process to the manufacture of chemical solutions, as instanced in the employment of gold and silver ribbon in bullion refining, copper ribbon in the manufacture of copper sulphate, and zinc ribbon in the cyaniding process. The chemical activity of ribbon metals is very remarkable; in the case of zinc, for instance, it is found that the ribbon form will reduce the ferric salts to the metallic state, and in nearly all cases metals in ribbon form will dissolve



Apparatus for Metal Sheet.

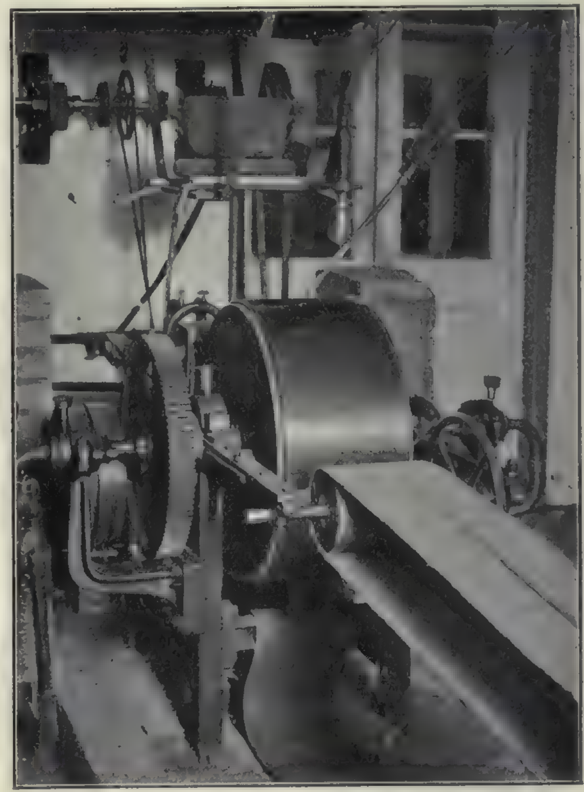
in a fraction of the time usually required. This is possibly not due merely to the large surface employed by the metal in ribbon, but is probably accounted for by the molecular strain set up in the course of manufacture. Ribbon metal has been successfully exploited, more particularly the application to pipe joint caulking and to bullion refining.

Ribbon Metal Apparatus.

The recent improvements in the ribbonising process, and the development of the process in its important application to the manufacture of sheet are of immediate interest. Originally ribbons were run from a single nozzle, and the possible size of the aperture of the nozzle was limited by the metal to be used and the ease with which that metal would flow when in a molten condition. Now, however, by an arrangement which employs the head of the molten metal itself in a vertical pipe, the metal is forced through small holes under pressure and a very fine ribbon is obtained. As many as 250 streams of metal can be led to one drum about 3 ft. in width, thus producing 250 continuous ribbons. The cost of manufacture is therefore very small, being little more than the cost of melting the metal; and the output from a given machine is far greater than at one time was deemed possible. In so far as the manufacture of lead and similar ribbons is concerned, there now seems little scope for improvement.

The possible employment of the process, as applied to the manufacture of wide sheets of metal, was at first looked upon as not very promising. Many experiments were tried. Whereas a round nozzle showed little tendency to be interfered with by any small piece of dross which might find its way into the nozzle, such an obstruction even for a moment in a wider slot for delivering the metal meant the destruction of the continuity and regularity of the sheet. It was found to be a difficult matter to arrange for the molten metal to fall evenly upon a wide revolving surface, but after exhaustive experiments it was found possible to supply the metal in a bath, one side of which was formed by the cooled rotating drum. The drum continuously froze the metal it came in contact with, and in its revolutions removed the solid sheet from the bath, the length of the sheet being only determined by the quantity of metal supplied.

As a result of the first crude, but successful, experiments, a new series of patents was applied for relating to the manufacture of sheet metal. The working out of the new method on a commercial scale has been continued, and to-day the Ribbon Metals Syndicate is in a position to manufacture wide and even continuous sheets of the low melting point metals.



Drum for Sheet Metal.

There is still much to be done. As yet only a few of the fields open to the invention have been covered; in fact, the very object for which the process was invented—the cheapening of the production of white lead—is for various chemical reasons not commercially complete, although satisfactory results have been obtained under laboratory conditions. The process has, however, achieved a commercial standing, which ensures the satisfactory carrying out of the very expensive experimental work yet to be undertaken. The production of sheet copper, sheet brass, and sheets of other high melting point metals, which are at present manufactured at a very high cost by elaborate rolling machinery, seems to be in sight.

One of the leading steel works engineers in the United States has commenced experiments towards the manufacture of ribbons and sheets of steel by a modification of the process.

It is impossible to say how far this process can be carried. It has opened up a new field in the treatment of metals. New uses of the process, which did not occur to us in the early days of the invention, are gradually opening up and being considered.

A USEFUL PUMP.

By J. G. Davis, B.Sc. (Eng.), A.C.G.I.

Although in this pump the principle of action is the same as in the ordinary plunger-pump, the compact form of construction and the reduction of losses due to slip and lack of balance should recommend it in cases where hand or small power pumps are used. The arrangement is indicated by the elevation and section in Figures 1 and 2 respectively. Two independently fitted pistons are virtually driven by cranks set 180° apart. This is effected by oscillating the short central link joining the connecting rod ends, shown in Figure 1, either by an eccentric as here indicated, or by a handle forming an extension of the link.

The motion of the said link in a counter-clockwise sense separates the pistons, filling by suction the space between them through the lower central port, and delivering at each end through the top ports.

On the return motion of the link, mutual approach of the pistons secures delivery at the top central port, and suction through the bottom end ports.

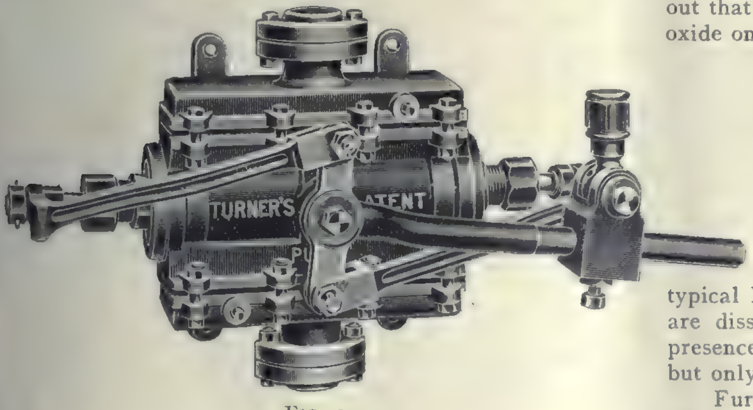


Fig. 1.

The attachment of two cup-leathers, back to back, to each piston ensures one always forcing, constancy of suction and delivery being attained. The absence of slip is supplemented by the condition of mechanical balance, resulting from the equality of the rates of suction and delivery at any instant, the central ports being double the area of the end ones.

Self-contained valve plates render repairs easy, and the leathers are protected from the bad effects of rust by brass-lining the pump.

With a foot valve, the pump will lift vertically to 25 feet, and will force up to 100 feet, according to the power.

The usual plugs are provided for draining or priming. For liquids prohibiting the use of leathers special pumps can be constructed. The largest size requires about one horse-power against a 50 feet head when dealing with 1,700 gallons per hour. Provision for increased capacity is made by a "twin-type" of pump, which, with the above lift, will deliver something over 50 per cent. more water with $1\frac{1}{2}$ horse-power.

It is questionable whether large pumps constructed on this principle would not prove costly in manufacture, but at any rate for such powers as mentioned it has certain useful features.

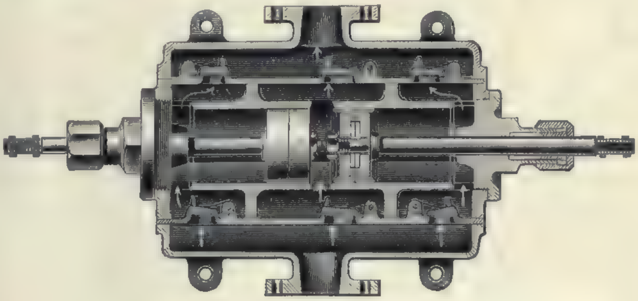


Fig. 2.

RUBBER AND RUBBER PRODUCTS.

Mineral Ingredients in Rubber.—The influence of the progressive addition of talc and zinc oxide is well illustrated in a recent publication by Clayton Beadle and Stevens. (*J.S.C.I.*, 1911, 30, 1421.) The point is brought out that there is a marked difference between talc and zinc oxide on the properties of the vulcanise rubber. The effect of zinc oxide is to directly improve the quality, the rubber being tougher and more resistant to stretching. Beyond a certain point the addition has practically no effect, except on the subpermanent set. This beneficial effect may be connected with the fact that the presence of this body seems to directly influence and increase the proportion of combined sulphur.

Talc may be regarded as an "inert filler." The typical hysteresis extension curves for zinc oxide and talc are dissimilar, but the results indicate that even in the presence of the latter, the combined sulphur is increased, but only in the ratio of 16-26 as compared with zinc oxide.

Further tests with magnesia showed similar results. The effect produced is an increase in combined sulphur in all cases. In the case of talc the increased percentage of sulphur is not, however, combined with a corresponding improvement in the rubber, but in some cases the reverse effect is observed.

NOTES ON CHEMICAL RESEARCH.

By The Editor.

CHAPTER I.—(*Continued.*)

When considering this general position the beginner must guard against the conclusion that startling discoveries result from a casual observation on the part of some investigator. This is not so. Many previous investigators had probably overlooked these same phenomena. Only a trained observer can appreciate their value, and take advantage of their occurrence.

It may be safely assumed, that under modern conditions, successful investigation has its origin in a basis of the closest reasoning, and only when this is accompanied by a careful survey of previous work, and a full consideration of the best conditions of working, can a successful issue be anticipated.

This view was certainly held by Faraday, when he said "that the world little knows how many of the thoughts and theories that have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination, that in the most successful instance not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realised."

It has therefore been generally agreed that no scientific discovery can with any justice be considered as due to accident; knowledge and training are essential before results which are worth consideration can be obtained, or what is perhaps of more importance, their true significance realised. The young investigator will do well to accept this position without question. Experience can only confirm it. It is important to realise from the first that discoveries are laboriously sought for; that they are the result of a direct and patient search. Having realised this important point false hopes are destroyed, and additional value given to the results obtained. It will act as an incentive to the student to make full use of facts which are already available, and to increase this in every possible way; and point to the only means by which success can be achieved.

The recognition of this fact is of great importance to the routine worker, for it indicates that there is always a reasonable chance of obtaining results by close observation. In standard methods of analysis the only safe means of detecting any remaining errors, or inherent defects, is by a comparison of the results obtained by constant repetition. This often leads to improvement by modification in detail. Such results become immediately useful. They may even bring to light new problems of a comprehensive nature, leading to further investigation on more general lines. Thus each type of worker has special methods for securing an increase in knowledge, which may be obtained in this case by applying the methods of experimental investigation to the every-day operations of the laboratory.

In experimental investigation great attention must be given to detail. Where this is not fully realised, conclusions may be drawn from premises which are either incomplete or incorrect. When these are made use of, confusion and uncertainty may result.

In industrial operations this may well be disastrous. Much time has been lost in attempting to apply such imperfectly worked out conditions on a manufacturing scale. The effect on the actual investigator of such partial success, or failure, is equally unfortunate and may lead to a corresponding lack of confidence.

The natural difficulties which surround an attempt to increase the scale on which an operation is conducted are sufficiently formidable in themselves. The data obtained in the laboratory under the best conditions are often not sufficiently definite for such an extension to be carried out without subsequent investigation. New difficulties come to the surface for the first time. These have to be dealt with by further research.

All possible care must therefore be exercised in the initial stage, and the laboratory results examined and checked in the smallest detail. In this way the presence of difficulties introduced through want of attention is reduced to a minimum.

The need of a sound training in research, and the methods of conducting it, is self-evident. It is an essential condition to success. The only point remaining for discussion is how far such training can be imparted to a student under university or college conditions.

Definition of Research.—Past experience has shown that it is difficult to define the exact nature of such work, and this has led to a good deal of uncertainty.

Research has been defined as a "wrestling with nature, a striving towards the limit of attainable knowledge." In putting forward this definition, Gore held that it consisted of observation, study, and experiment, in varied proportions.

Discovery has generally been defined as "a passing from the known to the unknown." It is considered that this result is achieved in the following cases*:—

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* Gore.

(1) When we perceive a new impression.
(2) When we observe a new fact.
(3) When we compare two ideas and observe a new similarity or difference.
(4) When we compare two propositions, and perceiving a similarity, or difference, infer a new truth.
(5) When we divide, or analyse, a compound idea and perceive a new, or more elementary one.
(6) When we combine two or more ideas together by an act of imagination, and perceive a new combination.
(7) When we permutate, or alter, the order of a new series of ideas, and perceive a new order.

When an attempt is made to define the exact relation between investigation and research it is difficult to arrive at a satisfactory result. The following statement recently set up to meet special conditions suggests, by inference, the nature of such difference:—

It is considered necessary that:

(1) Research as result of observation in experiment must result in the collection of new facts.
(2) It must involve an examination of the facts collected or phenomena observed, and the reduction of them to form in which they constitute an addition to knowledge.

It has also been held for practical purposes of definition "that work published by one of the learned societies may be treated as research."

W. M. Gardner has defined research as "a logical and original investigation inspired by imagination and directed by special knowledge."

Chemical research has been divided into two distinct branches, which deal respectively with investigation which has a theoretical or practical significance. Sir William Tilden has defined these respective spheres in the following terms:—

(1) The worker watches the operations of nature and puts questions in the form of experiments solely with the desire to find out her ways.

(2) Attention is given only to those laws, facts, and phenomena which can be made serviceable to man.

In the future this definition may require amending in the implied suggestion that the division between these two classes is of a hard-and-fast nature.

Under modern conditions of industrial research the interests involved in many cases are such, that the conclusions arrived at have often far-reaching theoretical importance. The great advance which has taken place in tinctorial chemistry would not have been possible without the aid of those chemists who have followed up this development from the commercial and industrial standpoint.

As time goes on, this dividing line will become less marked, and such a definition may possibly lose its present significance. This fusion of interests will follow with a realisation of the extremely complex and increasingly important status and significance of modern industrial research. The connection between the two branches of pure and applied chemical research is already seen in the use made of theoretical knowledge of an advanced nature in industrial research, as in the actual working out of the attempt to fix nitrogen for industrial purposes by Caro and others, and the means thus offered for the establishment of many important theoretical conclusions.

If it were possible to discard the term research, and divide chemical investigation into the two main divisions of original and applied work, many of the past difficulties in definition and distinction might disappear; and with this condition a further advance might be noticed in the relationship existing between the two branches of pure and applied science.

EXPERIMENT *v.* OBSERVATION.—The investigator must understand the distinction involved in this expression. Observation is defined as a mere recording of phenomena as they occur in the ordinary course of nature. When this course is changed by the intervention of personal thought, resulting in action, we are said to experiment. These two conditions have been defined by Herschell as "passive" and "active" respectively.

An experiment differs from an observation in the fact that the specially introduced conditions determine or influence the direction and character of the results obtained. When considering this point the student may refer to "The Study of Chemical Constitution," by Freund (1904), Cambridge Physical Series, where the subject is treated in a manner which enables the influence of experimental evidence to be easily realised.

A final estimate of the relative value of observation and experiment is impossible under present conditions. It varies in different branches of science. It has not the same value in chemistry as in medicine, where observation is seemingly receiving increased attention at the expense of experiment. Observation has possibly a greater value in a new industry than an old one. It is still indispensable to the industrial chemist, and is being used with far-reaching results.

Its specific value is generally recognised. It is often a necessary, if preliminary, step towards investigation of a strictly experimental order.

Thus, the term empirical, when it is applied to the method of observation, does not always possess the adverse significance which is sometimes ascribed to it. By its aid early observers were able to carry on certain reactions on the industrial scale, long before the question of a scientific control was thought of, or any reasonable explanation of the actions involved could be given. Industry based on such practice was for long ages a determining factor in the advance of civilisation.

In certain cases where this condition still rules it must be regarded as an indication that the reactions involved defy the investigator's skill to explain them.

Thus it happens that complicated processes are in operation to-day which to a great extent run on empirical lines. The investigator must guard against adversely criticising such methods in cases where it is clear that the conditions of scientific control are not yet fully worked out, and empirical methods are still necessary. Industrialists must not be blamed if they continue the use of such methods against the time when it is clearly proved that alternative ones can be followed.

The value of observation on empirical lines can be perhaps best realised in the industrial world. In many cases it represents the only method available. The value of the experimental method may be accepted as beyond all question, but the time has not yet come when the empirical method can be dispensed with in the industrial world.

There is an intermediate stage in the development of scientific investigation or progress, where, as Faraday has suggested, "ideas which may have a provisional basis on experiment are so often the shades of a speculation—impressions on the mind which are allowable for the time as guides to thought and research," although "often their apparent fitness and beauty vanish before the progress and development of real natural truth." The way of the investigator is one of successful application of thought or knowledge. It is not rendered less difficult by any fast definitions or preconceived ideas which may cramp thought and interfere with progress along lines of least resistance.

The industrialist experiences a certain satisfaction in those processes based upon observation, which have never failed to furnish him with definite results, even if their operation has not yet been explained in terms of modern scientific thought.

The advance of industry was securely fixed on a basis of observation long before the experimental method was brought into action. It ruled supreme for long ages. Possibly its success accounted for a delay in the realisation of the value of the experimental method, which has now been fully demonstrated, and is so self-evident under modern conditions.

New processes working on an extended manufacturing scale are undoubtedly springing up on all sides, which owe their existence to the results of modern experimental investigation. These could not have come into existence on a basis of mere observation. They are direct results of an investigation conducted on original and definite lines. This method has given results which could never have been realised under the old *régime*. The new method has supplemented the other, and has carried us further along the road of industrial success.

It is certain that the future belongs to the experimentalist. It is right to emphasise this in every way; but the value of observation in the past, as in the future, must be fully recognised by the investigator, who is to understand the past history of industrial progress, Observation rightly carried out will ever illumine the work of the investigator.

TRAINING IN METHODS OF RESEARCH.—The value of the experience gained by those engaged in original work is beyond dispute. In some quarters the advantage which the average student may secure by engaging in such work during his college course is regarded as uncertain. When considering this point it is well to remember that the actual conduct of original work must not be confused with an experimental knowledge of the general methods of conducting investigations in the research laboratory.

The absence of this knowledge may leave the worker at a disadvantage. The young investigator entering the industrial world has to face problems calling for immediate investigation. In order that this position may be dealt with, a knowledge of certain procedure is essential. The training required for this work will be found on examination to be almost identical with that necessary for the conduct of original work. In both cases unknown conditions have to be considered. It is not at this stage that the phenomena dealt with are sufficiently defined for it to be known whether their investigation will entail original research, or only call for the application of data published by previous experimenters.

(*To be continued.*)

PERSONAL AND OTHER NOTES.

It is announced that Prof. Sir W. Ramsay, LL.D., F.R.S., has resigned his appointment as Professor of Chemistry at University College, London. Prof. J. O. Arnold, of the Birmingham University, has been appointed by the Board of Education to the post of Government Examiner in Metallurgy.

Professor W. A. Bone, F.R.S., of Leeds University, has been appointed Professor of Fuel and Refractory Materials in connection with a new Department of Chemical Technology, now being established in the Imperial College of Science and Technology at South Kensington, S.W.

Dr. G. T. Beilby has offered a research prize for the best contribution on present knowledge of foam-cell structure, the question which might have an important practical bearing on foundry practice.

Dr. G. T. Morgan has been appointed Professor of Chemistry at the Royal College of Science, Dublin.

Mr. W. H. Roberts, F.I.C., has been appointed Public Analyst for Blackburn.

Mr. Collingwood Williams, F.I.C., has been appointed Public Analyst to the County of Lancaster.

We are informed that Vol. III. of "Researches on Cellulose" (1905-1910), by Cross and Bevan, now in the press, has been delayed to include some important work published in 1911.

SCIENTIFIC CONTROL OF TOBACCO GROWING IN RHODESIA.

By E. ROSS TOWNSEND.

THE cultivation of the "fragrant weed" in Rhodesia dates back long prior to the British occupation of the country in 1890, and was practised on a more or less extensive scale by the natives all over the country, but principally in the Inyoka District by a tribe of natives, who paid a yearly tribute of tobacco to the Paramount Chief, Lobengula, the head of the Matabele nation, who largely use tobacco principally in the form of snuff.

SPECIMEN OF RHODESIAN TOBACCO.

After the occupation of Mashonaland by the British South Africa Company, several of the Colonial farmers, who trekked into the Enkeldoorn, Charter and Melsetter Districts, cultivated tobacco on a small scale for their own consumption, on the lines which had been in vogue in the districts of the Transvaal and Cape Colony, whence they had migrated. The results proving encouraging, they extended their operations and obtained very satisfactory returns from their crops, which were manufactured into what is generally known as "Transvaal" pipe-tobacco, for which there was a ready sale for local consumption at remunerative prices.

This was the beginning of the tobacco industry amongst Europeans in Rhodesia. The fact had been established that the soil and climate were in every respect suitable for the production of a high quality leaf, and it only remained to improve the methods of cultivation and curing. These being somewhat crude and faulty, produced a rather heavy tobacco, lacking in aroma. This tobacco satisfied the local demand, but was not in a position to command a wider market, so that in 1905 the Government decided to send an official of the Department of Agriculture to the United States thoroughly to study and report upon the cultivation and curing of tobacco in that country.

The result of this officer's investigations was embodied in a very full report, which was published by the British South Africa Company, and freely distributed amongst farmers and others interested in the industry. A quantity of reliable seed of the best varieties of tobacco, suited to the local conditions, was procured by the Administration and distributed amongst those farmers who were willing to grow small crops experimentally, on the most up-to-date methods of cultivation and curing, under the direction of the official who had made himself personally acquainted with the best American methods.

The outcome of these efforts was, that in 1906 a small crop of Virginian leaf was produced of a quality considerably in advance of that hitherto grown in the country, and more suited to the requirements of cigarette manufacturers, and for a better class of pipe-tobacco.

FIELD OF TOBACCO.

Facilities were also provided by the British South Africa Company for the proper grading, conditioning, and marketing, of the tobacco crop by the establishment of a central warehouse, with the most modern appliances for the purpose under the management of a tobacco expert, to which the planters could send their crops to be put into condition for marketing, and to be marketed by the warehouse management at reasonable cost. This marks the third stage in the development of the tobacco industry in Southern Rhodesia, which has made steady and marked progress, as regards the quantity and quality of leaf now being produced.

It was also found by experiment that a high quality tobacco of the Turkish type could be successfully grown, and its cultivation extended. As a result of further experiments, it was found that the leaf could be much more satisfactorily and expeditiously cured by using flue-curing barns, artificially heated. The majority of growers have now adopted this method of curing their leaf.

TABLE I.

THE FERTILIZERS USED IN THE EXPERIMENTS AND PRICES.

FERTILIZER.	Manurial constituents present.				Price per ton. (2,000 lbs.) at Salisbury, Rhodesia.		
	Nitrogen.	Phosphoric Oxide.		Potash.			
		Soluble in water.	Insoluble in water.				
	%	%	%	%	£	s.	d.
Nitrate of Soda . .	15	—	—	—	17	10	0
Dble. superphosphates	—	42	4	—	16	12	6
Sulphate of potash . .	—	—	—	50·	18	10	0
No. 1 Proprietary . .	8	20	4	10·	23	10	0
No. 2 Proprietary . .	3	9	3	11·	14	0	0
No. 3 Proprietary . .	1·8	4·6	3·3	·8	17	10	0
No. 4 Proprietary . .	10	9	—	38·	32	0	0

As a result of the improved methods of cultivation, curing and conditioning, an increasing quantity of leaf of a higher and more uniform grade is being produced; this finds a ready sale amongst manufacturers of cigarette and pipe-tobacco in South Africa.

In 1910, the Tobacco Company of Rhodesia and South Africa, Ltd., was formed (in which the British South Africa Company holds a substantial interest, and has the right of nominating two members on the Board of Directors), for the purpose of developing the tobacco industry, both as planters and manufacturers. This Company took over the warehouses and management already established, and has built additional warehouses and a factory, equipped with modern appliances. An efficient staff of experts, in both branches, is maintained, capable of dealing with all present requirements.

FLUE-CURING BARN.

TABLE II.

EFFECT OF FERTILIZERS UPON YIELD OF TOBACCO PER ACRE. SEASON 1910-11.

Plot.	Manure per acre.	Cost of Dressing per acre.	Yield of cured leaf per acre.	Increase per acre
			lbs.	lbs.
1	No manure	—	396	—
2	6 tons Kraal manure (farmyard)	—	356	40
3	100 lbs. nitrate of soda	17/6	363	33
4	100 lbs. superphosphates	16/7	see footnote	—
5	40 lbs. sulphate of potash	9/3	392	4
6	100 lbs. of soda 100 lbs. of double superphosphates	34/1	see footnote	—
7	100 lbs. nitrate of soda 40 lbs. sulphate of potash	26/9	517	121
8	100 lbs. double superphosphates 40 lbs. sulphate of potash	25/10	737	341
9	100 lbs. nitrate of soda 100 lbs. double superphosphates 40 lbs. sulphate of potash	43/4	847	451
10	310 lbs. No. 2 Proprietary	43/4	792	396
11	250 lbs. No. 3 Proprietary	43/4	583	187
12	135 lbs. No. 4 Proprietary	43/4	702	306
13	184 lbs. No. 1 Proprietary	43/4	51	455

A portion of leaf from No. 4 was baled by mistake with a portion of that from No. 6, and in consequence the yield per acre on each of these plots cannot be given. The average yield of the two plots was 721 lbs. per acre.

Rhodesian-grown tobacco, of both the Virginian and Turkish types, is also being manufactured in England on a small scale and is highly regarded by smokers. As, however, the South African market is a protected one, a minimum duty of 3*s*. per lb. being levied on all tobacco entering the Union, to which, however, Rhodesia has free access, being a subscriber to the Customs Union of South Africa, the locally grown leaf competes very favourably against the imported article, and commands prices considerably higher than those obtaining in other countries where similar quality of leaf is produced.

TABLE III.

REPORT OF MANAGER, TOBACCO WAREHOUSE, SALISBURY, ON THE QUALITY OF THE LEAF OBTAINED FROM EACH PLOT.

Plot.	Colour.	Average length of leaf in ins.	Quality.
1. No manure . .	Only fair (varying from yellow to dark brown).	12	Poor.
2. Kraal manure .	Do. do.	12	Do.
3. Nitrate of soda only.	Slightly inferior to no manure plot.	12	Do.
4. Superphosphates only.	Very satisfactory. Bright.	15	Very fair.
5. Sulphate of potash only.	Similar to nitrate of soda plot.	14	Poor.
6. Nitrate of soda and superphosphates.	Yellow . . .	14	Fair.
7. Nitrate of soda and sulphate of potash.	Very fair . . .	14	Do.
8. Superphosphates and sulphate of potash.	Good, bright yellow.	14	Very fair.
9. Nitrate of soda, superphosphates and sulphate of potash.	Good, bright lemon yellow.	16	Good shape of leaf. Very satisfactory.
10. No. 2 Proprietary.	Very fair . . .	14	Fair.
11. No. 3 Proprietary.	Do. do. . . .	14	Do.
12. No. 4 Proprietary.	Very fair . . .	14	Fair.
13. No. 1 Proprietary.	Good, bright lemon yellow.	15	Do.

GENERAL NOTE.—The leaf of plots 9 and 13 is much superior in quality, colour and general spread, to that of the other plots.

As an illustration, the whole of the 1909-10 season's crop, which was sold at public auction in January, 1911, by the warehouse management, realised an average price of 1*s*. 5¾*d*. per lb. for Virginian leaf, the maximum price realised for this class of leaf being 3*s*. per lb., and for Turkish leaf 2*s*. 9*d*. per lb.; one grower obtained an average price of 2*s*. 4*d*. per lb. for the whole of his Virginian crop. The average yield of cured leaf varies in different parts of the country, and may be said to range from 450 lbs. to 700 lbs.

Manurial experiments, conducted by the Agricultural Department on small trial plots of one-tenth of an acre each, have demonstrated the fact that the yield can be largely increased by the use of certain fertilisers, the quality of the leaf being not only maintained, but greatly improved.

The preceding tables are based upon experiments conducted by the Rhodesian Agricultural Department, and have been published in the Official Journal for public information. They give the constituents of fertilisers used, their effect upon yield and quality of leaf, and should be of great value to planters in the future as a guide in selecting a fertiliser for use on their plantations.

NEW METHODS OF ANALYSIS.

By HARLEY KNIGHT, F.C.S.

Rapid Analysis of Copper.

OF late years a good deal of attention has been paid to the analysis of metals and their alloys by electrodeposition, and one of the great drawbacks encountered in the early days was the necessarily long time that the electrolysis occupied, owing to the comparatively low current density that was found compatible with good, sound adherent deposits, about 1 ampere per 100 sq. cm. of cathode surface being commonly employed.

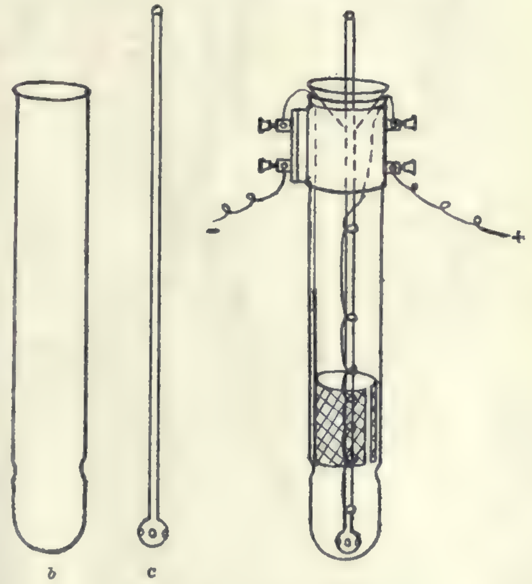


FIG. 1. GAS AGITATION METHOD.

Many years ago it was discovered that by rapidly rotating the cathode, or by causing the electrolyte itself to circulate rapidly round a fixed cathode, that a much higher current density could be employed.

The rotating cathode has been used by many chemists, but has not been universally adopted, owing to the many adherent disadvantages, such as having to run a motor and the complications in order to avoid loss by spraying.

Although at first sight it does not seem likely that it would be an easy matter to circulate the electrolyte in an actual determination, yet it is by means of a rapidly moving solution. F. Fischer, C. Thiele and E. Strecher (*Analyst*, 1911, 600, 601, from *Zeitsch. Electrochem.*, 1911, 17, 905-908) have actually attacked the problem.

So long as the electrolyte is moving rapidly enough to disengage the liberated gas from the surface of the cathode, the same required conditions are supplied as in the case of the rotating cathode, and the above authors have found that this is the case if a rapid stream of some inert gas is bubbled through the solution at the time of electrolysis, or the gas liberated by the current itself made to cause the agitation of the liquid, and so allow of a higher current density being employed.

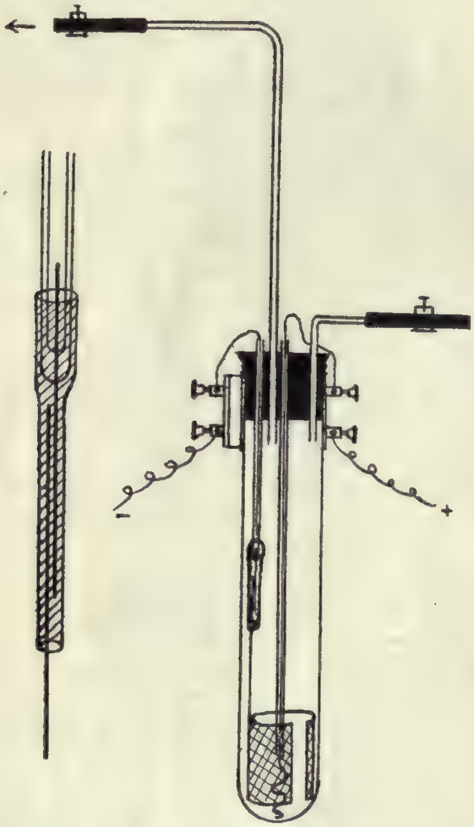


FIG. 2. REDUCED PRESSURE METHOD.

In the first case a brisk current of hydrogen is made to pass into the electrolyte and has proved satisfactory.

The apparatus used is shown in the accompanying sketch, and consists of a long glass tube *b* 30 cm. × 4·5 cm., having three indentations 5 cms. from the bottom, which serve to support and keep the cathode in position.

The gas leading tube *c* is 35 cm. long and of 5 mm. bore, and has a 2·5 cm. bulb blown at the bottom, which is pierced by a number of small holes, including one at the bottom. This tube also serves to support the anode, which is simply a platinum wire which is wound round it, the windings being closer in the vicinity of the cathode.

The cathode is a platinum gauze cylinder, open so that it can be slipped into place after the anode has been fixed. It has a length of platinum wire welded on so that it can be connected to the terminal screws as shown.

After the connections are made a stemless funnel is dropped over *c* and serves to keep it central and also to act as a spray catcher.

The speed at which the gas is generated is such as to raise the liquid from the top of the cathode, which is its normal height, to about 5 cm. above it.

If the temperature at which the solution is electrolysed is about 60°C., there is sufficient condensation to wash down the walls of the apparatus.

With a current density of 1·2 amperes from 0·15 to 0·2 grams of copper or nickel can be deposited in 10 minutes.

The second method is one that has been personally investigated, and for rapid and accurate results is to be commended. In this the agitation is effected by means of the gases evolved by the electrolysis being made to assume many times their normal volume by working under reduced pressure. The apparatus is similar to that described in the former method, and is shown in the illustration; it differs chiefly in not having any indentation to support the cathode, and having the funnel supplanted by a rubber stopper perforated with four holes, through which pass the necessary glass tubes.

The long bend is connected to a water pump or other suitable suction apparatus, and at the end of the operation can be pushed down to the bottom of the tube and the electrolyte and wash water being drawn off through it. The short bend is used for sucking in the wash water.

The two remaining tubes have platinum wire sealed into their extremities, one of which forms the anode and the other being used as the cathode holder.

The terminal connections are made by filling these last-mentioned tubes with mercury and passing loose wires into them.

The tube acting as cathode holder is shown on an enlarged scale, and has a piece of capillary rubber tube pushed on over it and serves to make a very good connection to the stem of the cathode when it is inserted, and has the advantage of being very easily disconnected.

At a temperature of 70°C. and using an ordinary glass water pump capable of giving 28″ reduction, a current density of 2—3 amperes may safely be used. This will deposit 1 gram of copper in 50 minutes.

The electrolyte should contain 1·5 cc. of sulphuric acid per 100 cc., and the presence of small quantities of nitric acid will not materially effect the deposition.

The platinum cathode is made of very fine gauze and is about 5 cm. high and 4 cm. in diameter.

CORRESPONDENCE.

The Metric System.

To the Editor of THE CHEMICAL WORLD.

SIR,—Perhaps you can draw attention to the growing importance of the use of this system to chemical manufacturers in this country. In many factories in the North this system is already in use for internal working. It has been stated that at least a year is wasted in teaching the less scientific system in our schools. Surely this is a reason in itself why the change should be made.

Yours faithfully, CHEMICUS.

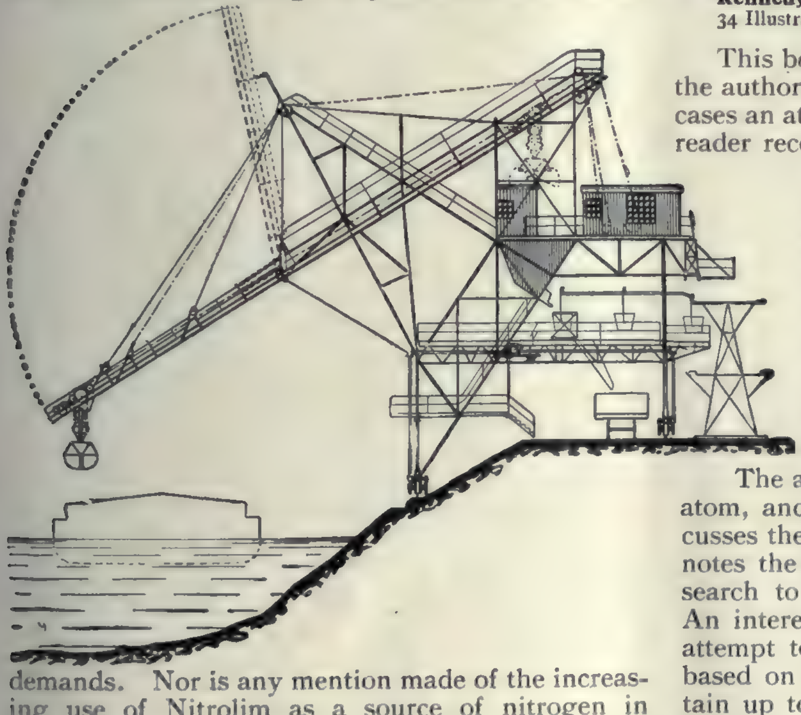
London, 22nd January, 1912.

REVIEWS OF BOOKS.

MANUFACTURE OF CHEMICAL MANURES. By J. Fritsch. Translated by Donald Grant. SCOTT, GREENWOOD & Co., 1911. Chapters XVII. Pages 322+xii. 69 Illustrations, and 108 Tables and Index. Price 7s. 6d. net.

This is the translation of a well-known work which deals not only with theory, but also with practice. The translator has added numerous practical notes. The work opens with an account of the principal phosphate deposits of the world, and phosphoric acid and its compounds. The drying and enrichment of phosphates, and the superphosphates and soluble phosphates are then discussed and described.

Compound manures, bone dust, the manufacture of phosphorous, basic slag, nitrogenous manures, cyanamide and nitrate of lime are then considered. The details concerning the latter products are not very satisfactory owing possibly to the fact that the original work dates from 1909. No mention is made of the recent increasing use of cyanamide (Nitrolim) as a fertiliser, and as a raw material for ammonia (ammonium sulphate or nitrate) which in its turn is used as a fertiliser, nor the very large present and prospective increase in the works manufacturing this product to meet recent demands. Nor is any mention made of the increasing use of Nitrolim as a source of nitrogen in compound manures as a substitute for sulphate of ammonia and nitrate of soda, to which its relatively reasonable price and suitability entitles it. Interesting particulars are given on the recovering of nitrogen from "spent wash."



The last part of this work deals with Nitrogenised Phosphate manures, and Potassic manures. The handling of raw materials and finished products is satisfactorily dealt with, as will be seen from the accompanying illustrations. The translation, which is well done, will be welcomed by those interested in this increasingly important subject.

SOME CHEMICAL PROBLEMS OF TO-DAY. By R. Kennedy Duncan. HARPER BROS., 1911. 8vo. Chapters XI. 34 Illustrations.

This book may be considered as a supplement to the author's "Chemistry of Commerce," as in both cases an attempt is made to bring before the general reader recent advance in theory and practice.

In the first chapter we get an insight into the conditions which exist in America, and on which the author's Industrial Scholarships scheme is based. The matter is dealt with a free hand, and many interesting problems are discussed. From the nature of the inquiries recorded it is evident that the scientific organisation of the industrial world in America is below that of Europe. This is what Prof. Duncan is anxious to alter.

The author then considers the question of the atom, and the "whitherward of matter," and discusses the trend of chemical invention, in which he notes the growing tendency for the leaders in research to protect by patent the results obtained. An interesting chapter deals with Prof. Duncan's attempt to increase the yield of natural camphor, based on his observation that the dry leaves contain up to 2·52% of camphor, and the suggestion is made that this material shall be obtained from this source, instead of the wood.

The chapter on the relation between Chemistry and Manufacture in America, is a reprint. The presence in the universities of "vocational" professors, who, in addition to their academic position, carry on their ordinary practice, seems to approximate to the conditions which to a great extent, obtain in Germany.

The final chapter deals with details of the Industrial Research scheme as it stands to-day, and to which reference is made elsewhere.

The book is evidently intended to impress the every-day reader and manufacturer with the importance of recent progress.

WHO'S WHO IN SCIENCE. Edited by H. H. Stephenson.
J. & A. Churchill, London, 1912. 302+ix pages, including Classified Index. Price 6s. net.

This compilation of the names of about 10,000 of the leading scientists will under present-day conditions be a serviceable addition to the library. A list of the World's Universities, is followed by short biographical particulars of actual workers in Science. We have tested the book with a certain number of names selected at random, and find that generally speaking the list is a fairly complete one. The final classified index is a useful feature.

THE CHEMISTRY OF THE COAL-TAR DYES. By Fay.
Constable & Co., Ltd., London, 1911. Chapters XIX.+vi; and Index. Price 16s. net.

This book runs on the usual lines of such text-books, dealing with coal-tar and its products, the hydrocarbons and their derivatives, and then the dyes themselves, classified in the usual order. The chapters on Aniline black, the alizarine dyestuffs, indigo and the sulphur dyes should be of special interest at the present time.

In the chapter on Aniline black, the reference to the recent researches on its constitution by Willstater and Moore, Green, and others, is indifferently treated, the work of the latter investigator not even being mentioned, and this chapter is hardly up to the standard of the remaining ones. The one on indigo is more satisfactory in this respect.

The chapter on the sulphur dyes is also incomplete, and little or no reference is made to many important dyes of this group. A chapter on mordants, if possibly out of place, is useful in its contents, and an interesting one on experimental work gives simple examples which the student who is working alone may follow up, for the actual details of working are given.

The chapter on the "Seven food colours" permitted in U.S.A., has chiefly a local interest. The type used for formulæ, both ordinary and graphic, is particularly clear and well adapted to the use of the student. The book is a useful one, and can be recommended to the student, and those wishing to obtain an insight into the chemistry of dyestuffs.

THE CALORIFIC POWER OF GAS. By J. H. Coste.
Griffin & Co., 1911. Griffin's Scientific Text Books. Chapters IV, divided into 22 Parts. Pages 297+vii. 57 Illustrations and Appendix.

This is a workmanlike book, as one would expect from the fact that it is written by one who has had the opportunity of trying and testing most, if not all, of the calorimeters described.

The first part of the book is taken up with the historical survey of changes in the methods of manufacturing and using gas, and the "positive" testing of gases according to the Acts from 1860-1910, which govern it.

The second chapter, or rather section, is devoted to the consideration of calorific standards, as they exist to-day. This section deals with a discussion on the calorific values of gas, both gross and nett, the calculation of the value from results of analysis, composition of gas, and causes of variation in composition of coal-gas. This is followed by an exceedingly lucid account of the various calorimeters in use to-day, and the varying sources of error affecting the "flow" type of calorimeter. The "continuous" and other types are then discussed, and finally useful hints are given on the choice of methods and appliances. It is pleasing to see that this text-book is satisfactory in every respect. It may safely be consulted by all those interested.

Books Received.

"Metallurgy," by W. Borchers. Translated from German by W. T. Hall and C. R. Hayward. Pages 271, including Index. 218 Illustrations. John Wiley & Sons. New York, 1911. Price 12/6 net.

"Microbiology," edited by C. E. Marshall. Pages 724+ix., including Index. Chaps. 47, with 128 Illustrations. J. & A. Churchill, London, 1912. Price 10/6 net.

"The Chemistry of Bread-Making," by J. Grant. Pages 224+vi., including Index. 4 Plates. E. Arnold, London, 1912. Price 5/- net.

"The Manufacture of Sulphate of Ammonia," by G. T. Calvert. Pages 153+vi., including Index. Chaps. 11, with Appendix. 97 Illustrations. John Allan & Co., 1911. Price 7/6 net.

"A Text-Book of Practical Chemistry for Technical Institutes," by A. E. Dunstan and F. B. Thole. Pages 331+viii., including Appendices and Index. Chaps. 18, with numerous Diagrams. Methuen & Co., Ltd., London, 1911. Price 3/6.

"An Elementary Text-Book of Metallurgy," by A. H. Sexton. 5th Edition. Pages 263+xi., including Index. Chaps. 20; divided into two parts. 71 Illustrations. C. Griffin & Co., Ltd., London, 1911. Price 6/-.

"Leçons de Cristallographie," by G. Friedel. Pages 310+iv., with Index and Appendix. Chaps. 6, with 383 Figures. A. Hermann et Fils, Paris, 1911. Price 10 francs.

"Introduction à l'Etude de la Spectrochimie," by G. Urbain. Pages 248+iii., including Index. Chaps. 7, with 70 Figures and 9 Plates. A. Hermann et Fils, Paris, 1911. Price 10 francs.

Traité Complet d'Analyse Chimique Appliquée aux Essais Industriels," by J. Post and B. Neumann. Translated into French by G. Chenu and M. Pellet. 2nd Edition. Pages 468. Chaps. 38, with 56 Figures. A. Hermann et Fils, Paris, 1912. Price 15 francs.

"Who's Who in Science," edited by H. H. Stephenson. Pages 302+ix., including Classified Index. J. & A. Churchill, London, 1912. Price 6/- net.

"THE ACTION OF THE RESPIRATORY ENZYMES OF SAUROMATUM VENOSUM SCHOTT."

By DR. TH. WEEVERS.[1]

(*Communicated to the meeting of September* 30, 1911.)

THE production of heat in the spadix of *Aroideæ* has been long known; it was first observed by Lamarck in 1777. Since it has been repeatedly investigated[2] and was found to be a process involving absorption of oxygen. Kraus[3] showed that in the tissue starch and sugar are used up, whilst CO_2 and sometimes organic acids are produced.

In 1901 Hahn,[4] in a short paper, stated that in the press juice of *Arum maculatum* an enzyme is present, which decomposes glucose with formation of carbon dioxide. After removal of the CO_2 by boiling, the liquid still had an acid reaction. He observed neither formation of alcohol in the air, nor in a hydrogen atmosphere, although in the latter case also the glucose was decomposed and CO_2 was formed.

This short note was not followed by any detailed communication, so that it seemed to me desirable to investigate whether the interesting results of Hahn's inquiry were confirmed with other objects.

Sauromatum venosum Schott appeared to me to be suitable for investigation on account of its size and the ease with which it can be obtained.

For the purpose of orientation, I rubbed up in a mortar the fertile as well as the sterile part of a spadix, and made the pulp up to 250 cc. with water. One half of this was at once boiled for 5 minutes; to the other half a few drops of toluene were added, and after the flask had been closed by a plug of cotton-wool it remained for 48 hours at 16°C. Its contents were then boiled, a certain amount was filtered off from both halves and the reducing sugar as well as the organic acids were determined in the filtrate. (Indicator phenolphtaleïne, which gave a sharp endpoint.)

In the flask in which autolysis had taken place were found 10 mg. glucose and 8·0 cc. 0·1 N. acid, in the control flask 80 mg. glucose and 0·5 cc. 0·1 N. acid.

So this preliminary experiment showed, that in the autolysis sugar was decomposed and organic acid formed. In further experiments, however, a different plan was adopted. After the tissue had been rubbed fine in a mortar, I strained the pulp through the finest plankton gauze; the fluid thus obtained, which was almost perfectly clear, was heated with a threefold quantity of 95% alcohol, the precipitate filtered, washed out with alcohol and dried in the air in the dark till all the alcohol had evaporated (about 12 hours).

The powder then obtained, *i.e.*, a crude enzyme or a mixture of enzymes was used for further experiments and was found to have a strong glucoclastic action; similarly the pressed-out, dried mass had this action, even after treatment with acetone.

The former result was unexpected because Hahn, with a crude enzyme prepared in the same way from *Arum maculatum*, only obtained a very weak action, and because more investigators in this field hold the view, that destruction of cell-structure and treatment with alcohol weakens the action of the respiratory enzymes in tissues rich in water, and even destroys it.

Zaleski[5] says: "Ueberhaupt kann man sagen, dass die Zerstörung der Struktur am stärksten die Atmung derjenigen Objekte vermindert, die im Zustande tätigen Lebens sich befinden, oder wasserreich sind. Noch stärker wird die Kohlensäureausscheidung zerriebener Objekte nach dem Behandeln derselben mit organischen Lösungsmitteln wie Aceton und Alkohol vermindert, und manchmal hört diese ganz auf."

This cannot therefore be generally valid, at least not for the object here investigated, which is rich in water and is in condition of active life.

In exactly the same way I have been able to obtain from the fresh leaves of *Sauromatum* a crude enzyme, that decomposes glucose while forming CO_2 and organic acid. The action was however weaker.

The dried preparation of the enzymes was generally used at once for the experiments; after some days the activity diminished, although it did not completely disappear.

If I made the preparations by treating the press juice with acetone, I obtained a precipitate that was similarly active after removal of the acetone.

The experiments were made as follows.

The enzyme preparation was mixed in a flask of 750 cc. capacity, with 1% glucose solution sterilised by boiling, and with some drops of toluene. In experiments with access of air, a regulated current of air sterilised[6] and free from carbonic acid came into the closed flask, and the issuing current of air passed first through a calcium chloride apparatus and then through a potash bulb (with $CaCl_2$ tube). The increase of weight of the potash bulb indicated the amount of carbonic acid formed, whilst in some experiments this was also shown qualitatively with baryta water.

For the experiment in a hydrogen-atmosphere the flask was first filled with hydrogen that had been purified with dilute-potash, after which, with the necessary precautions the enzyme, a solution of sugar and a few drops of toluene were introduced. Then during the experiment a purified current of hydrogen passed through the flask and carried the CO_2, which had been produced, into the potash bulbs; at the end air free from CO_2 passed through, in order to be able to determine the increase in weight of the bulbs.

The experiments always lasted 48 hours,[7] only once did I determine the CO_2 produced in successive periods of 3 and 6 hours, but found no great differences. Indeed, the method was not suitable for successive determinations with small intervals, since after terminating the experiment by heating the liquid in the flask above 70°C., one ought to pass the current through for a short time longer in order to get all the carbonic acid into the potash bulbs.[8]

The liquid in the flask was always boiled for a moment at the end of the experiment and the first distillate was tested by means of the iodoform reaction for alcohol, the result was always negative, both in the aerobic experiments and in those in a hydrogen atmosphere.[9]

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[1] *Akademie van Wetenschappen te Amsterdam.*

[2] Sassure, *Ann. Sc. Nat.*, 1822.
Vrolik and de Vriese, *Ann. Sc. Nat.*, 1836.
Garreau, *Ann. Sc. Nat.*, 1851.

[3] G. Kraus, *Abh. Naturf. Ges.*, Halle, 1882, *Ann. Jard., Bot.* 1896.

[4] M. Hahn, *Ber. Chem. Ges.*, Bd. 33, 1900.

[5] W. Zaleski, *Atmungsenzyme der Pflanzen*, *Bioch. Zeitsch.*, Bd. 31, 1911.

[6] For this purpose the air passed through strong caustic potash, to which some toluene had been added.

[7] The experiment with a preparation from the spadices took place in daylight; since organic acids in aqueous solutions are gradually decomposed by light, the quantities found are somewhat too small.

[8] If traces of CO_2 should remain behind, the result would naturally be too low.

Then the liquid was cooled, made up to a definite volume and filtered. I determined the quantity of organic acid in the filtrate, equally that of the glucose, the latter one before and after boiling with dilute hydrochloric acid.[10] Control experiments, in which the liquid was boiled immediately after mixing, gave the total quantities of reducing sugar and organic acid at the beginning of the experiment; the latter in the experiments with the alcohol precipitate from the spadices amounted to 0·1 cc. 0·1 N. at most.

Below are given some of the experiments.

I. Experiment in CO^2 free air.
400 mg. crude enzyme, acetonic preparation.
Decrease of glucose from 437 to 360 mg. = 77 mg.
Increase of the potash bulbs by CO_2 production 34 mg.
Increase of organic acids 9 cc. 0·1 N.

II. Experiment in CO_2 free air.
750 mg. pressed and dried tissue powder, that had been treated with acetone.
Decrease of glucose from 457 to 217 mg. = 240 mg.
Increase of potash bulbs by CO_2 production 140 mg.
Increase of organic acids 25 cc. 0·1 N.

The glucose can be more strongly decomposed, so that after boiling with HCl only traces of reducing sugars remain; in these experiments K_2HPO_4 was generally added, which according to the investigations of Zaleski and Reinhardt[11] stimulates the action of the enzymes. This made a determination of organic acid difficult, because the potassium phosphate had an acid reaction and the quantity added perhaps partly entered into combination during the experiments.[12]

III. Experiment in H atmosphere, potassium phosphate added.
800 mg. crude enzyme (alcoholic preparation).
Decrease of glucose from 437 mg. to 2 mg. = 435 mg.
Increase of potash bulbs by CO_2 production 165 mg.

IV. Experiment in air free from CO_2, potassium phosphate added.
1,500 gr. pressed out material, which had first been dried at 60°C.; then acetone had been poured over it and it had again been dried at 60°C.
Decrease of the glucose from 485 mg. tot 5 mg. = 480 mg.
Increase of potash bulbs by CO_2 production 187 mg.

Finally two more experiments with the crude enzyme from the leaves; no potassium phosphate was added.

V. Experiment in air free from CO_2.
1,200 gr. crude enzyme (alcoholic preparation).
Decrease of glucose from 375 mg. to 340 mg. = 35 mg.
Increase of potash bulbs by CO_2 production 27 mg.
Increase of organic acid from 1 cc. to 3·2 cc. = 2·2 cc. 0·1 N.

VI. Experiment in hydrogen atmosphere.
1,200 gr. crude enzyme (alcoholic preparation).
Decrease of glucose from 375 mg. to 343 mg. = 32 mg.
Increase of potash bulbs by CO_2 production 14 mg.
Increase of organic acid from 1 cc. to 3·5 cc. = 2·5 cc. 0·1 N.

(*To be continued.*)

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[9] Only a few drops were distilled over. Generally the odour indicated traces of butyric acid.

[10] The glucose determinations were made according to N. Schoorl's method, *Ned. Tijdschrift voor Pharmacie*, 1899. The quality after boiling with HCl was generally as great as before boiling; the former values are given.

[11] W. Zaleski and H. Reinhardt, *Biochem. Zeitschr*. Bd. 27, 1910.

[12] Compare the investigations of A. Harden and W. J. Young, *Biochem., Zeitschr.*, 1911.

Institute of Chemistry Lectures.

At a meeting of the Institute of Chemistry, held at University College, London, on Friday, January 26th, Sir William Ramsay, K.C.B., presiding, a lecture was delivered by Mr. Charles F. Cross, B.Sc., F.I.C., on "Cellulose." He said that in the text-books of Chemical Science "Cellulose" takes an inconspicuous place; in other words, the labours of specialists in this field have not contributed much to rank as systematic science. The advance, however, in the classification of a wide field of natural products and phenomena has resulted in formulating constitutional problems of necessarily great moment, and this is a contribution of "capital," if not, as yet, of "income."

Cellulose, as a basis of manufacture, takes by contrast a predominating position. Primary manufactured products at factory cost represent values approaching £200,000,000 per annum for the United Kingdom. Cellulose derivatives as the basis of smokeless powders, as an indispensable auxiliary to photographic art, and as the raw material of "celluloid," occupies various positions of unique and critical importance.

England more than maintains its competitive position in this huge field of industrial activity. Chemists are disposed to be pessimistic in contrasting the relative advance of Germany in chemical industry. But in the general perspective, the figures for gross production, as for the very special section of dye-stuffs and organic synthetic products, are insignificant. Taking Cellulose as a typical colloid, and enlarging our view to include industries based upon colloids, *e.g.*, silk, wool, leather, gelatin, starch, paints and varnishes, india-rubber, etc., their preponderance is evident. In other words, excluding the metals, human industry is chiefly busy in transforming colloidal substances of entirely natural origin. Hence, a second feature of cellulose chemistry of great importance to the rising generation.

The *Normal* cellulose is still rather a laboratory term and product, but of as obvious importance for cellulose industry, as a gold standard for commerce. The lecturer insisted on its recognition, and demonstrated that the so-called "pure" cellulose in the form of chemical filter papers represented about 90—95 per cent. only of "normal" purity.

A normal cellulose is of the utmost importance in the explosives industry, and the supposed identity of "rag cellulose" (cotton and linen) with "normal cellulose" is an illusion.

"Lignocellulose," or wood substance, connotes a field of work of extraordinary attractiveness both scientific and industrial. After propounding a schematic constitutional formula for "lignone," and applying it to interpret characteristic reactions, the lecturer suggested that the type of combination of lignone with cellulose to form the complex "lignocellulose" may in time modify our views of chemical combination. The interpenetration of two colloidal systems may produce the effects of combination by "residues."

Attention was then directed to the industrial preparation of wood pulps, and their typical forms—"soda" pulp, "sulphate" pulp, and "sulphite" pulp—these processes being taken as illustrating the balance-sheet of industrial production, as establishing factory costs, and as an extension of the chemist's habitual methods of quantitative analysis.

The second lecture will be given on February 23rd.

COMMERCIAL AND GENERAL NOTES.

America's Production of Sulphuric, Nitric and Mixed Acids.

ACCORDING to a preliminary statement of the thirteenth census of establishments engaged in the manufacture of sulphuric, nitric and mixed acids, there were in 1909 42 establishments against 32 in 1904, an increase of 31%. The capital invested, as reported in 1909, amounted to $18,726,000, representing a gain of 47% over $12,762,000 in 1904. The value of products increased only by 9%, which seems out of proportion to the growth of the capital invested and the expenses. These amounted to $910,000 in the last census year against $713,000 in 1904, an increase of 28%.

The total production of sulphuric acid, reduced to 50° Baumé was 2,797,723 tons in 1909 and 1,869,446 tons in 1904. Of this total, 933,848 tons were reported in 1909 against 467,614 tons in 1904, by establishments making it as a chief product, an increase of nearly 100%; 621,801 tons (against 433,373 tons in 1904) by establishments primarily manufacturing other products, and 1,242,074 tons (against 968,455 tons) were consumed in establishments where made.

The total production of nitric acid was 138,086,565 pounds in 1909 and 108,380,387 pounds in 1904, or an increase of 27%.

The total quantity of mixed acid manufactured in 1909 cannot be ascertained, because the amount consumed in the establishments where made was not reported, but the quantity manufactured by establishments making it as a by-product was 57,182,168 pounds, against 65,331,327 pounds, a decrease of 12%.

The German Glycerine Convention adopts the I. S. M., 1911.

The German Glycerine Convention in Berlin has decided to adopt the I. S. M., 1911. It will be remembered that the efforts of the makers of crude glycerine resulted in the formation of an expert committee, on which the makers, consumers and public analysts were represented. This committee made investigations as the result of which a series of methods of analysis was agreed to, which is known as the International Standard Method, 1911 (I. S. M., 1911). The German Glycerine Convention considered these methods the most reliable ones, and has decided to give preference to all public chemists and analytical institutions working according to these methods.

New Tax on Oleomargarine in the United States.

A campaign which is expected to be an active one throughout this session of Congress was started by the introduction of a new Bill. This has the purpose of bringing about changes in the law relating to the manufacture and sale of oleomargarine, in order to protect consumers and dealers against fraud, and to afford the Bureau of International Revenue more efficient means for the detection of fraud and the collection of revenues. These changes in the rates of taxation on oleomargarine or margarine, as it is called in England, are intended to meet the point so frequently raised by the butter manufacturers, that no objection would be made to the competition from artificial butter, if that product were placed on the market for precisely what it is.

The present law, taxing uncoloured margarine ¼c. per pound, and artificially coloured 10c., was cumbersome in its administration, and since the manufacture of margarine in connection with vegetable oils, which give it a butter-like colour, has been developed, the original purpose of the law has been defeated. The new Bill proposes a flat tax of ⅛ c. per pound on all makes of margarine, irrespective of their colouring or nature, and provides for the sale and packing of the product in sealed and stamped packages. The new Bill has the hearty approval of the manufacturers and commission merchants.

The Potash Question in America.

In consequence of the rapidly increasing consumption of potash in America, the Government is prosecuting a diligent search for domestic deposits of this article. The Geological Survey has not yet succeeded in discovering any valuable potash mines, but its work has been productive of good results in establishing the existence of potash in rock or rocky formations close to the earth's surface. Whether this potash can be extracted to commercial advantage remains to be seen.

One of the directions in which the Geological Survey has prosecuted its search recently, is in connection with the salt-producing industry. The potash salts found in the brine of bittern of the salt wells of the eastern sections of the United States have been thoroughly investigated, and a report has been prepared showing that practically every salt-producing locality has been visited and its refuse product analysed. The report says that ordinary rock salt may either overlie or underlie soluble potash salts, and that both of these conditions exist at Stassfurt, Germany. There is no indication, however, that the Geological Survey has received any great amount of encouragement from its present investigation, although it is stated that a highly concentrated bittern from the salt plants of Northern Ohio hold out sufficient promise to warrant further inquiry.

Another find which has recently been recorded by the Geological Survey in connection with the potash inquiry, was the discovery of beds of alunite, a hydrous sulphate of aluminum and potassium near Marysvale, Utah. This vein of what is commonly known as alumstone, has been analysed as containing 11·4% of potash, and therefore is considered to be a product capable of profitable development under certain conditions.

These investigations, in widely separated sections of the country, together with the inquiries into feldspar deposits which were recently referred to in these columns, indicate the persistence with which the search for potash is being carried on. The vast importance of the potash question for the United States can be measured by the fact that the imports of German potash during the first 10 months of 1911 were $3,000,000 more than during the same months of the previous year.

Eucalyptus Oil for Ore Concentrating.

An enormous demand has recently arisen for eucalyptus oil in the mining industry, and the Australian producers are making special efforts in order to satisfy the growing requirements of the consumers. One of the best markets for eucalyptus oil suitable for ore concentrating is South Africa. Steps are already being taken to produce the oil more cheaply, and reducing the high cost of collecting the leaves. By substituting suitable machinery for hand-labour, there seems a possibility of producing eucalyptus oils which could be sold at about 6*d*. per lb. M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

22745/10. W. G. HEYS, Manchester. (Communicated by the Nitrogen Company, Ossining, New York, U.S.A.) *Nitrogen Compounds.* 1 October, 1910.

The invention relates to the electrolytic production of an alkali metal cyanide, cyanamide or the like, and consists in first forming a carbide of a more reactive metal than the desired alkali metal, converting such carbide into a cyanogen compound, and in then replacing the metal of the cyanogen compound by the desired alkali metal. (3 claims, 4 Figs.)

26777/10. A. H. PERRET, Paris. *Vanadium and like compounds.* Dated, under International Convention, as 24 November, 1909.

This invention relates to a process applicable to metals, such as vanadium, molybdenum and tungsten and other rare metals of the same class, such as niobium and tantalum, which form several different oxides, and the highest oxide of which is soluble in molten alkalis or alkaline carbonates. The process consists, in principle, in treating the metal in question in an open furnace in a medium which is at the same time superoxidising and alkaline so as to convert the metal in question into its highest degree of oxidation, and thus to render it soluble and more easy to separate. When the oxidation is finished, the mass is poured into a vat filled with cold water or with a lye obtained from a previous treatment, so as to obtain almost immediately the solution of about one-half of the oxide of metal and to facilitate the ultimate pulverisation of the mass. (3 claims.)

27218/10. T. MCCLELLAND, Glasgow. *Sterilizing Milk.* 23 November, 1910.

The sterilization of milk is effected, in accordance with this invention, by causing it to pass in contact with carbon or other non-metallic resisting material in the form of particles, granules or the like and through which an electric current is passed. (1 claim, 4 Figs.)

27253/10. M. ARNDT, Aachen, Germany. *Testing Air.* 23 November, 1910.

The main object of the invention is to provide an apparatus for indicating the presence of particular kinds of gases in a gaseous mixture by means of a liquid re-agent that changes colour when applied upon a testing medium which is exposed to the action of the gaseous mixture. The liquid re-agent and a reserve supply of the testing medium, such as thread, are stored in a container shut off from the atmosphere. The thread sucks the liquid re-agent out of the container and the liquid re-agent passes along the thread to that portion which is exposed to the action of the gaseous mixture. (14 claims, 5 Figs.)

28178/10. R. WALLBAUM, Berlin. *Emulsifying Asphalt.* 3 December, 1910.

The invention relates to a process of emulsifying asphalt, coal-tar pitch, petroleum pitch, paraffin, montan wax, Japan wax, or mixtures of these substances in a simple way, and, in accordance therewith, one of the substances mentioned, or a mixture of the substances, is fused together with saponifiable substances, such as resin, naphthenic acid, fatty acid or the like; the hot-fused mixture is either added, under energetic stirring, to a boiling solution of an alkali salt or ammonia salt of resin, a fatty acid, or naphthenic acid, which solution, preferably, contains an excess of alkali or ammonia, or is treated with a free alkali solution, at or above 100°C. (4 claims.)

28553/10. J. MEURANT, Liege. *White Pigments.* Dated, under International Convention, as 1 April, 1910.

The process of producing white oil, enamel or linoleum paints consists, according to this invention, in heating lithopone with soluble catalysers or fluxes which are first dissolved in water and mixed with the lithopone, then in raising the mass to a suitable temperature and subsequently removing the catalyser or flux by washing, leaving the insoluble lithopone, which is now stated to possess increased covering properties. (1 claim.)

60/11. J. Y. JOHNSON, London. (Communicated by Badische Anilm und Soda Fabrik, Ludwigshafen, Germany.) *Purifying Gases.* 2 January, 1911.

Gases are purified electrically and in accordance with this invention, by passing them through an electric field in which a brush discharge is taking place and afterwards through another electric field in which no brush discharge, or practically no brush discharge, is taking place. (4 claims, 3 Figs.)

1247/11. C. RACHOU and E. CHAUMAT, Camares, France. *Indigo Dyeing.* Dated, under the International Convention, as 18 January, 1910.

A process for indigo dyeing with hydro-sulphite consists, according to this invention, in impregnating the wool or other textile material with bath liquor in a dyeing tank, then taking the impregnated material out of the tank and placing it automatically upon an endless belt conveyor to a wringer, by which it is wrung immediately and before the liquor has time to become oxidised. (3 claims, 2 Figs.)

10536/11. THE FIRM FRANZ SCHONWEITZ, Hamburg, Germany. *Imitation Marble.* Dated, under International Convention, as 29 April, 1910.

Objects made of marble, stone or majolica are imitated, according to this invention, by enclosing a pasty mass as hereafter described between two glass plates. The pasty mass is prepared as follows :—Liquid water glass coloured with transparent aniline and tar colours is admixed with dry pulverized water glass until a pasty mass is obtained. (1 claim.)

15181/11. A. H. PERRET, Paris. *Vanadium and like Compounds.* Dated, under International Convention, as 24 November, 1909.

Vanadium, tungsten, molybdenum or other similar metals are extracted from any liquid containing the said metals in solution. For instance, liquids obtained in the process described in specification No. 26777/10 (see abstract above). After having brought the liquid to 45°B and having treated it with sulphuric acid of 53°B until, while still strongly alkaline, almost the whole of the silica has been precipitated, its temperature is raised to 80°C., and vanadic acid obtained by a previous operation is introduced. The liquid is then filtered and the acid of the metal contained in the liquid obtained by the filtration just mentioned is precipitated by sulphuric acid. (2 claims.)

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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12th AUGUST, 1865.

IT is permissible at the present juncture to remember that the work of the late Lord Lister was founded on observations made by a chemist: and to realise the immense step which was taken when the first application of the antiseptic treatment was made on 12th August, 1865. The first trial was made in a case of compound fracture. This having a satisfactory issue, it was followed by others.

His experiments were founded on the earlier discovery of Pasteur, who was censured by the French Academy of Science "for his presumption as a chemist, in venturing into the realm of biology and giving utterances to opinions which were contrary to accepted doctrines." Subsequent work on ferments helped to suggest the germ theory of disease—the highest pathological discovery of any age.

Lister followed up the work of this great chemist and applied the principle involved to practical surgery. It is difficult to realise the conditions under which operations were conducted in the days when Lister made his first experiments. It is sufficient to say, that the same operating tables and instruments were used for the dead and the living.

Lister felt that circumstances were against his work: that forces were at work which made all the care and attention in hospital work of so little avail, that the deaths in an open field hospital were actually less than in the hospitals themselves. He almost despaired at times. "I have seen," he said, "a man die within two days of an accident as plainly poisoned as if he had taken a fatal dose of some toxic drug." In his early experiments he used pure carbolic acid, ultimately reducing this to 5% solution.

Those who follow the more recent aseptic treatment which dispenses with the presence of antiseptics on the face of the wound, still acknowledge that the original conditions set out by Lister have to be satisfied.

Not only have operations been facilitated: countless amputations have been prevented. Before the germ theory was understood surgeons were helpless before certain classes of wounds. It was considered unwise to make an attempt to save the limb in compound fracture. To-day no surgeon would consider its removal.

Lister tells the story in his own words:—

"When Pasteur had shown that putrefaction was fermentation caused by the growth of microbes, the problem assumed a more hopeful aspect. If the wound could be treated with some substance which, without doing too serious mischief to the human tissues, would kill the microbes already contained in it, and prevent further access of others to the living state, putrefaction might be prevented, however fully the air with its oxygen might enter. I had heard of carbolic acid as having remarkable deodorising effects upon sewage, and having obtained from my colleague, Dr. Anderson, a sample of this product, then little more than a chemical curiosity in Scotland, I determined to try it in compound fractures (a compound fracture being one in which there is a wound of the skin communicating with broken bones). Applying it undiluted to the wound, I had the joy of seeing these formidable injuries follow the same safe and tranquil course of healing as simple fractures, in which the skin had remained unbroken. At the same time, we had the intense interest of observing in open wounds what had previously been hidden from human vision—the manner in which subcutaneous injuries are repaired—dead parts, even dead bones, being replaced by living tissue."

The advent of this discovery reduced the work of the surgeon almost to an exact science. It has been claimed that "after Lister, it was possible to affirm that no one shall die as the consequence of an operation correctly performed. The unforeseen was no longer to be reckoned among the causes of death." Thus through the work of this distinguished surgeon the natural limit of that of the chemist has once more been defined. This example indicates that his influence is world-wide; and that there is practically no experimental work which can profit by the neglect of the general principles laid down by the followers of this science.

Science and Commerce.

In the present day there still seems much uncertainty as to the value of the service which a student trained at a scientific institution has to offer. This has been recently the subject of rather severe comment in the pages of our contemporary, the *Engineer*.

Although the results obtained by research in Chemistry have an extraordinary interest from a theoretical point of view, and to an extent have thrown light upon the working conditions of the Universe; yet it may be said that the practical application of the results obtained, and their influence on the advance of civilisation, is our chief concern.

It is therefore useful to note a case recently made public, in which the results obtained in commerce through the direct aid of Science are specified, especially when these are of so successful a nature as those mentioned by the Earl of Erroll. In the case in question, the result of an investigation, carried out in one of the Universities on strictly scientific lines, led to an additional profit of £23,000 in the year's operations of an important industrial undertaking.

When considering the satisfactory results obtained in so many cases, it is difficult to account for the relatively inferior position occupied by the Chemist as compared with the Engineer, when gauged by the rough, but essentially practical test of £. s. d. It is not difficult to recall cases of consulting engineers who derive an income of £20,000 to £50,000 per annum, from their practice. It would be difficult to find many chemists who occupy a similar position in this country.

When the facts are examined in some detail, it may be granted that certain definite conditions exist which facilitate the working of the consulting engineer. As in the case of the architect, he deals with projects at the constructional stage. There is little doubt but that these factors have to a great extent influenced the quality of the men who have entered the respective professions. For after all, money counts in the modern world, even if it only means the power to conduct further scientific research under satisfactory conditions.

There is, however, little doubt but that Chemistry is offering increasing attractions for the man, who is in all ways capable of taking his place in a profession, which demands many other qualifications than those of mere knowledge of fact, and technical ability.

It is necessary for those who wish to secure the services of suitable men, to let it be generally known that posts will be open for those who are well qualified. That certain leading industrial concerns are willing, and indeed, anxious to retain the services of competent men of the right kind, and that the remuneration offered to those who succeed will be of such an order, that the men holding such posts will be able to occupy a social position comparable with that affected by the followers of the other professions.

This point is realised in certain directions, and this fact has only to be generally known for the profession of chemistry to attract its fair share of men who are willing to qualify for such posts by a four or five years' course at one of our leading Universities, with possibly a post graduate course in which specialisation is attempted.

The conditions which govern scientific education can now be practically determined on a basis of past experience.

Technical education which turns out men with a knowledge based on certain phases of industrial life, will supply a product corresponding to the training. The Chemist-in-Chief must have a training based on a wider experience, which can only be obtained in a University, which gives a thorough training in the general principles of chemistry.

* * * * *

Teaching of Dead Languages.

While the question of the teaching of dead languages is being discussed, it may be as well to consider whether there is not a scientific side to the question. It may be that a boy under the age of 16, should not be asked to learn any language which cannot be taught in great part by the conversational method. If this is so, French or German should take precedence over Latin or Greek, which should not be taught until the student can realise the utility of its study. In this connection the following opinion recently expressed by a correspondent in the *Times* may have some interest:—

"The myth is, that in education the choice of subjects does not matter, that faculties can be trained by any medium requiring the use of desirable powers, and that in some mysterious manner the faculty will overflow, or be adaptable to other uses than those in which it is trained. Thus it is seriously maintained that mental gymnastics in Latin will benefit the reasoning power of judgment in human affairs."

It is a pity that practical trials cannot take the place of interminable discussion on professional lines. A dozen schools adopting the new method to the exclusion of the old, would practically demonstrate the relative value of the two systems of teaching, which may be defined respectively as the experimental method, and the force draught system of mental gymnastics.

As Professor Turner has pointed out, a classical education may produce men of the broadest culture, but it also produces men of the narrowest type. This is perhaps another way of stating the personal factor. If Latin is to be taught to the average schoolboy the method of teaching must surely conform to certain definite rules. These can hardly be stated here; but it is evident that some of the older methods of instruction in this, and kindred subjects, belong to the days which are rapidly passing away.

FUEL CALORIMETRY.

BY J. H. COSTE, F.I.C.

THE branch of calorimetry which is of greatest interest to the chemical technologist is undoubtedly the determination of the calorific power of fuel. In modern industrial concerns the economical purchase and full utilisation of fuel are factors which largely determine commercial success. It must be borne in mind that it is not sufficient to buy fuel at a price commensurate with its heating value, but care must be taken that only a minimum amount of that value is allowed to escape unused. The temperature and composition of the escaping products of combustion must be considered, as well as the quality of the combustible. In almost all cases the latent heat of vaporisation of the water produced by combustion of the hydrogen in the fuel and of moisture associated with it will be lost, in addition to the sensible heat of the gaseous products. Therefore the *net* value will usually approximate nearer to the actual amount of heat utilised than will the *gross*, although it is not necessarily the fairer value to return, nor in the case of solid fuel is it easy to determine directly.

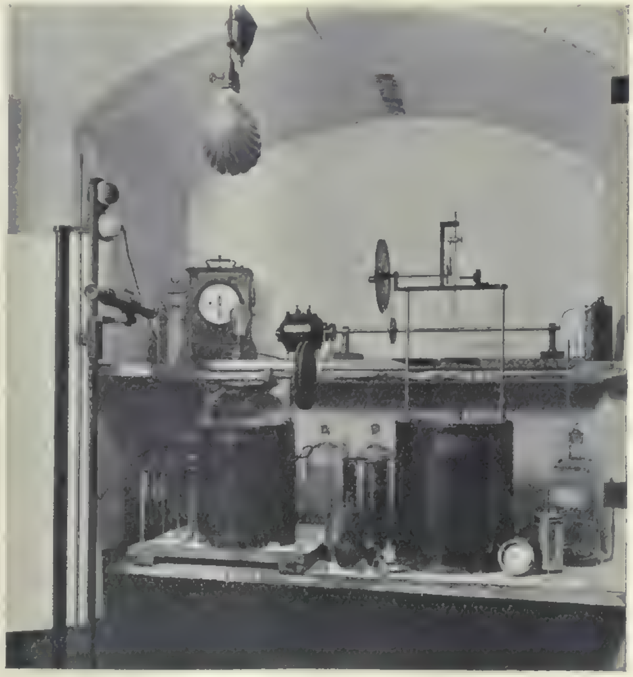

FIG. 1.

In parts of London, in Paris, and in some American States and cities the calorific power of the gas supply is regulated by statute. The coal contracts of some large power-raising undertakings, *e.g.*, the London County Council Tramways, are based on a standard of calorific power and moisture, with an adjustment of price for variations (within prescribed limits) above or below the standard. The determination of the calorific power of fuel is therefore a matter which is likely to arise at any time in the course of a general or industrial chemical practice, and, although the problem of fuel calorimetry superficially considered is only a matter of either (1) analysing a fuel and calculating its calorific power from the respective amounts and heats of combustion of its constituents, or (2) burning it and measuring all the heat evolved in the process, both methods in practice offer certain difficulties which are not lightly overcome. It is seldom that the proximate composition of a substance is so easily ascertainable that its calorific power can be calculated with accuracy. In the case of gases the uncertainty of the true nature of the unsaturated hydrocarbons, which may vary from ethylene to benzene, introduces a weak point, although a value approximating to that of propylene or rather higher, say 670 calories gross or 600 calories net per cubic foot of moist gas at 60° F. and 30″, gives results which are usually within 2% of the truth. Again, the various modifications of Dulong's formula for calculating the calorific value of coal from its ultimate analysis, are not only based on very slender foundations, but like the calculations for gases require before they can be used that a great deal of delicate analytical work should be done, as all who have tried to make accurate analyses of coal gas, or to determine the carbon, hydrogen, nitrogen, oxygen and sulphur in coal will agree. It is in almost every case better to make a direct calorimetric determination.

There is no doubt that for the complete combustion of solid fuel no other method is as certain as that of burning it with a sufficiently large excess of oxygen under greatly increased pressure, *i.e.*, about 25 atmospheres. Berthelot, who started by attempting the combustion of organic solids for calorimetric purposes in a glass vessel through which a stream of oxygen was passing, found that carbon was deposited on the sides of the vessel at times, and that the gaseous products were not always fully oxidised. As a result of this experience he designed the strong metal combustion chamber, now well known in many modifications as the calorimetric bomb. It is true that with some kinds of bituminous coal fairly good results can be obtained with the various low pressure oxygen calorimeters, of which William Thomson's is the earliest, and Rosenhain's probably the best, and certainly the most modestly described. It would be inadvisable, however, for a worker with any of these instruments to use his results for any other than internal purposes; it would be very rash to quote them against results obtained with a bomb calorimeter. The oxidising mixture type of calorimeter, such as Lewis Thompson's, is by no means useless, but usually unburnt solid carbon is left in the partly fused mass, and remains, with copper oxide, etc., when the alkaline salts are dissolved; an allowance should be made for this. The bomb calorimeter is, without doubt, the only one for serious work which is to bear challenge by other workers.

The various patterns of bomb calorimeter sold in this country are, I believe, all good; Hempel's is perhaps the least satisfactory, but very good work can be done with this. One is not, therefore, placed in the invidious position of recommending any one pattern to the exclusion of all others. Whichever pattern is selected it should not be one in which the calorimeter vessel is surrounded by a wooden tub. A large water jacket, the capacity of which is several times that of the calorimeter itself, is the best means of insuring that any effect which fluctuations of the room temperature shall have on the calorimeter itself shall be both very small and regular. If it is probable that determinations of sulphur will be required to be made in the products of combustion, a porcelain-lined bomb should be chosen.

It is, of course, highly desirable that calorimetry should be carried out in a fairly large room of constant temperature, but this is not always possible, nor is it absolutely necessary. The writer found that in a small room, heated by a gas fire so that its temperature rose 5° C. during one hour, the mean rise of temperature of a calorimeter protected by a not very large water jacket, externally lagged with white enamelled "cork carpet," and with a further outer metal jacket and intervening air-space, was only 0·0017° C. per minute. During the worst period the error due to this cause on a determination, the duration of which would be 4 minutes, would have been about 0·3%, if corrected for the observed change of temperature during an equal preliminary period, or about 0·7% if this variation were neglected. If a calorimeter with its water jacket were to be surrounded by another larger water jacket from which it was suitably insulated by an air-space and supporting blocks of wood, cork or ebonite, the effect of variations of room temperature would be extremely small. The water intended for use in the calorimeter itself should be kept in Winchester quarts or other suitable vessels placed close to it.

A good stirring arrangement, preferably driven by electrical or water power rather than by hand, is necessary. The up-and-down horse-shoe pattern of stirrer is simpler than, and at least as good, as the helical pattern.

A thermometer which can be read to 0·01° C., must be used; one giving finer readings is preferable. It should be calibrated or a certificate of comparison with a standard instrument obtained from the Reichsanstalt or the National Physical Laboratory. The usual rise of temperature in an experiment should be about 2° C., so that it is desirable to obtain a really good instrument. For technical purposes it is probably immaterial whether the pattern favoured by English and French makers, graduated in the stem, or the German enclosed pattern be used. Some workers who use the latter type adopt the 6° Beckmann (for a discussion of thermometers see Huntly Jour. Soc. Chem. Ind., 1910, page 917). It is necessary to use a reading telescope or a lens such as is supplied with the Boys gas calorimeter, as the error due to parallax may be considerable. In a laboratory well equipped with electrical appliances the use of a resistance or thermo-electric thermometer is well worthy of consideration. They offer advantages over the mercurial type.

The determination of the water equivalent of the system forming the calorimeter proper—water vessel, stirrer, bomb, the immersed portion of the thermometer, and the water—is best made by the worker himself. The chemist will find the combustion of weighed amounts of pure substances of which the heats of combustion are well known the most convenient means of doing this. Benzoic acid and cane sugar are probably the best substances for this purpose, and Fischer and Wrede's figures, 6,328 and 3,954 small calories per gram respectively, are the most reliable. If due correction for radiation and other regular errors be made by the use of the Regnault Pfaundler formula, the water equivalent found as the means of several experiments can be used for all experiments made under any (reasonable) conditions. If, however, it is known that all experiments (1) can be made with a steady initial temperature (or if correction is made for the rise of temperature, due only to surroundings, during an experiment), and (2) they will be of approximately the same duration, a water equivalent based on the mere observed rise of temperature can be obtained. This figure multiplied by the rise of temperature obtained in any future experiment will give the amount of heat evolved by the weight of fuel burnt in that experiment. It is convenient to use such a figure for technical work, although at times the use of the full correction is necessary. This is by no means as formidable as it is usually made to appear, but is merely a rational correction based on Newton's law of cooling.

When it is considered that a gram, or thereabouts, of fuel is burnt, and the results obtained thereon are taken as referring to consignments of, in some cases 1,000 tons, it is obvious that the method of sampling has an important bearing on the value of the laboratory work. Of course, the analyst is only responsible for the treatment of the sample as received by him, but even this requires careful attention if his ultimate small sample which is burnt in the bomb is to represent the bulk, perhaps ¼ cwt., or so, which is sent to him. It is important to be able to refer this back to the coal in the condition as to moisture content in which it has been weighed at the time of delivery, as well as to average truly the slaty matter, pyrites, etc., associated with it. Frequently, however, it is necessary for the analyst to advise as to the means to be adopted by his clients for sampling the bulk delivered. This is not an easy matter, and must be determined by the special conditions of delivery, as in many cases sampling has to be done during the processes of unloading a ship, barge or trucks, and filling of bunkers or other store. Samples of approximately uniform weight are taken from each so many tons, or from each truck as the side is let down, and the heap thus obtained, which may amount to some hundredweights, is reduced by quartation to a reasonably small sample for the laboratory (a good description of the methods of sampling coal is given in Professional Paper No. 48 of the U.S. Geological Survey: Report on the Operations of the Coal Testing Plant at the Louisiana Exhibition, 1904, Part I., page 32 ff.).

A few words as to the method of returning the results of calorific power of solid fuel may be of use. Whether expressed in (pound Fahrenheit) British Thermal Units per pound, or small calories per gram, matters little; the conversion from one to the other unit is determined only by the relation of the two thermometric scales. The question between figures referring to dry coal or to the coal as received is only a matter of calculation, except in so far as the methods of determination of "moisture" in coal are uncertain and purely empirical. It is rather to the inordinate number of figures returned that objection may be raised. The errors of careful sampling are probably seldom less than 2%. The average determination of calorific power with unexamined thermometers and with no correction or compensation for the effect of surroundings, is probably not reliable to less than 1%; the best determinations are probably good to ·3%, not less, and then there is an uncertainty of about ·25% as to the values to be taken for the substances used to calibrate the calorimeter. This uncertainty is not removed by an electrical calibration, since it is based on the varying values obtained by different workers for the relation of the calorie to the watt-second. The amount of heat generated during the passage of an electric current through a resistance placed in the calorimeter is found by determining (1) the difference of electric potential between the ends of the resistance by means of a standard cell and potentiometer; (2) the value of the resistance; and (3) the time of flow of the current. Then the heat generated $= \frac{E.M.F.^2}{R.} \times$ relation of calorie to the watt-second × time in seconds. The least accurate determination, that of E.M.F., unfortunately appears in a quadratic form, and the accuracy of the determination is reduced by one-half. Yet with all these sources of error, results are often returned, such as 12,951 B.T.U., or 13,679 B.T.U. It appears to be much more reasonable to state such results as 12·95 thousand B.T.U. and 13·68 thousand B.T.U., or even to be satisfied with the nearest 50 B.T.U., making the latter result 13·7 thousand.

Liquid fuels, as a consideration of the heats of combustion of the hydrocarbons likely to be contained in them will show, vary very slightly in calorific power per unit weight. It is therefore seldom that calorimetric examination of these is necessary.

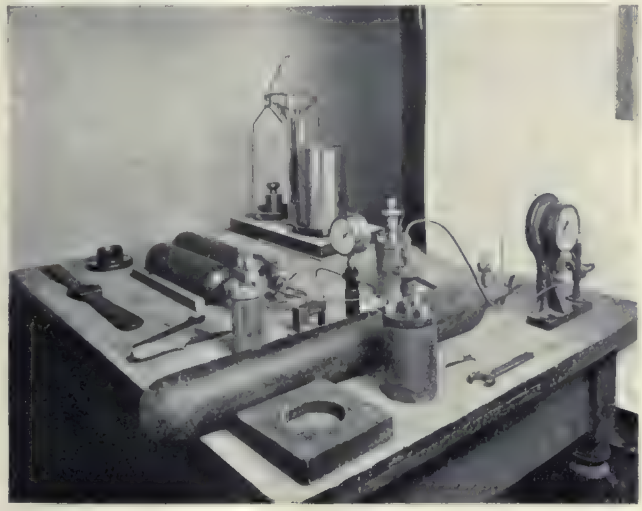

FIG. 2.

Bombc alorimeters with stirring gear driven by electric motor.—On the left is a calorimeter with helical rotating stirrer, shown at side; the gold-lined delta metal bomb, with the cover removed and placed in front of it, is shown to the right of calorimeter vessel; a spare bomb with cover bolted on is shown on the shelf in front of the minute clock. The small porcelain capsule in which coal is burnt, and the support for the bomb when in the calorimeter, are shown in the foreground. On the right is shown a calorimeter with up-and-down horseshoe stirrer (taken out and placed at right of calorimeter). The steel, porcelain-lined beaker-shaped bomb and its cover, with a platinum crucible and silica cup for use in the bomb, are also shown. The water vessel of this calorimeter is shown behind the delta metal bomb in the centre of the picture. A telescope for reading the thermometer is also shown.

Arrangements for filling bombs with oxygen from cylinders.—In Fig. 2 a bomb is being filled from a single cylinder, with which it is connected by small thick-walled copper tubing. A pressure gauge joined to a branch of this tubing indicates the pressure of gas in the bomb. Behind this another bomb is connected up to two cylinders. Thus a partly-emptied cylinder can be used for passing oxygen into the bomb until no more gas is passing. This cylinder is then shut off and the other less empty cylinder is used for filling until the requisite pressure of 25 atmospheres is indicated. The various appliances used for tightening up the joints between the bomb and its cover and for weighing the water in the calorimeter vessel are shown.

THE CATALYTIC ACTION OF REDUCED METALS.

By Arthur Clayton, D.Sc. (Lond.), A.R.C.S.

Among the numerous researches which characterise the progress of organic chemistry, there occasionally appears one, which by virtue of its brilliancy, ingenuity, or unexpected nature, forcibly arrests the attention of the chemical world. Such a piece of work is that of Sabatier and his collaborators Senderens and Mailhe. Some fourteen years ago, Sabatier and Senderens passed a mixture of hydrogen and acetylene over reduced nickel, and found that under these conditions the two gases entered into combination, the metal remaining apparently unchanged. It was at once evident that the union was due to the catalytic action of the nickel which, like catalysts in general, played a mysterious part in effecting the chemical change. It was soon found that other reduced metals, notably copper and cobalt, were also capable of acting in the same manner, nickel promoting the most energetic action, whilst copper was the least active in this respect.

Pursuing the line of research indicated by the results obtained in these experiments, the field of inquiry soon became extended and yielded an amazingly rich harvest, success following success with great rapidity. A glance at the subjoined list will reveal the varied types of compounds to which the catalytic method of reduction has been applied. Not only are unsaturated hydrocarbons converted into members of the paraffin series, but many other reactions are induced; thus aromatic hydrocarbons are reduced to derivatives of hydrogenised benzene, aldehydes to alcohols, and nitro-compounds to the corresponding amines.

Strangely enough, under certain conditions a totally different class of reaction takes place; for instance, if the vapour of a primary alcohol is passed over heated copper, an aldehyde and hydrogen are produced, and in a similar manner secondary alcohols yield hydrogen and ketones. The preparation of aldehydes by the convenient method just described, and the production of aniline from nitrobenzene, form striking examples of the utility of the catalytic action of metals on organic compounds. In the reduction of nitrobenzene, water gas, or even purified coal gas may be substituted for the hydrogen, thus opening the way to a new and efficient method for the preparation of aniline. Another application, of analytical value, is met with in the identification of primary, secondary, and tertiary alcohols, these compounds being distinguished by their oxidation or dehydration products, which are aldehydes, ketones, and olefines, respectively.

The function of the reduced metals in inducing reactivity in organic compounds forms a fascinating subject for study and speculation, but as in the case of so many other catalytic actions, no satisfactory explanation appears to be forthcoming. The activity of the metal or catalyst in the process, like that of a living ferment, exhibits three distinct phases:—(1) The initial or preliminary phase which corresponds to a modification of the surface of the metal by the action of one of the vaporised compounds; (2) a normal phase during which the typical reaction takes place, and which usually extends over a long period; thus in the hydrogenisation of benzene to hexahydrobenzene the same quantity of nickel may be used continuously for at least a month; (3) the final stage, which corresponds with the decay of the activity of the metal, due to a change in its surface brought about by traces of sulphur or other impurity.

Table showing a few Catalytic Actions of Reduced Metals

Substance.	Metal.	Temperature	Product.
Hydrogen + Acetylene	Nickel	Ordinary	Ethane
,, + Ethylene	Copper	180-300°C.	Ethane
,, + Benzene	Nickel	180-220°C.	Hexahydrobenzene
,, + Nitrobenzene	Copper	300-400°C	Aniline
,, + Carbon Monoxide	Nickel	250°C.	Methane + Water
,, + Nitroparaffins	Nickel	150-200°C.	Amines
,, + Aldehydes	Nickel	140°C.	Primary Alcohols
,, + Ketones	Nickel	140°C.	Secondary Alcohols
,, + Phenol	Copper	330°C.	Ketohexamethylene
,, + Phenol	Nickel	230°C.	Hexahydrophenol
Alchohol (alone)	Copper	200-240°C.	Aldehyde + Hydrogen

In the course of the numerous experiments carried out by Sabatier and his collaborators, sidelights have been thrown on several subjects outside the immediate range of their investigations. Thus in view of the stability of the benzene ring during hydrogenisation, it is interesting to note that the reduction of pyridine is attended by rupture of the ring, normal amylamine probably being formed. This behaviour argues for a difference of constitution between benzene and pyridine, and thus forms evidence against Körner's formula for the latter substance; and although in itself this testimony is not sufficient to negative a formula well supported in other directions, yet as experience has so often proved, it is wise to keep an open mind on all questions connected with the constitution of organic compounds.

Another and exceedingly interesting question which has received illumination from these researches, is that of the origin of mineral oils. Various theories have been propounded from time to time to account for the existence of natural petroleums, some authorities considering them to be formed by the action of water on metallic carbides, whilst others have regarded them as being produced by the decay of animal matter far beneath the surface of the earth.

Sabatier and Senderens, however, found that when a mixture of hydrogen and acetylene is passed over reduced nickel heated to 200° C., there is produced a highly fluorescent mixture of hydrocarbons which has all the general properties of American petroleum. Further, if acetylene alone is similarly treated, a green liquid is obtained containing benzene and its homologues, along with styrene, paraffins, and hexahydrobenzenes, and therefore resembling Caucasian petroleum. These results led to the suggestion that in the interior of the earth the alkali metals and their carbides are formed, and that the action of water on these substances produces a mixture of hydrogen and acetylene, which then reacts with finely divided nickel, iron, cobalt, etc., giving rise to hydrocarbons in the manner described.

Whether or no this is the true explanation of the formation of mineral oils cannot be decided by experiment, but it is at least satisfactory to have a rational hypothesis on so interesting and important a subject.

In conclusion, it may be said that the work of Sabatier and his collaborators shows that it is not always advisable to pursue the more frequented paths of organic research, and that a bold venture in a new direction may be rewarded by discoveries, the magnitude of which could neither have been suspected nor foretold.

ARTIFICIAL PRECIOUS STONES.

By Noël Heaton, B.Sc., F.C.S.

The production of precious stones by artificial means has been a dream of mankind from time immemorial. The value of such stones is largely due to their rarity, and the labour and uncertainty attached to the highly speculative process of searching for them in the earth; and the possibility of artificial production offers an alluring prospect of rapidly acquired wealth.

In mediæval times much labour and ingenuity was expended in this direction, but the problem is by no means easy of solution, and in the absence of accurate knowledge of the nature and composition of the minerals could not be seriously grappled with; the methods attempted, based as they were mainly on superstition, resulted in invariable, failure

Moreover, this absence of accurate knowledge rendered a solution of the problem less necessary for the mere purpose of acquiring wealth, for it was a comparatively easy matter to produce *imitations* by means of glass which had sufficient superficial resemblance to pass muster for the real thing.

Since mineralogy became a science, however, the matter has been placed on a different footing, for in the light of present knowledge all such imitations are seen to be very inefficient, and, moreover, very readily detected.

I might mention, in passing, that the statement one hears so frequently as to modern "paste" being made so well as to deceive an expert is quite erroneous—any such imitation can be detected with certainty in a matter of a few seconds. The reason for this will be clear when we consider for a moment the properties common to all gem stones. In the first place, being transparent crystalline bodies of high specific gravity they possess considerable refractive power, the index of refraction ranging from 1·54 in the case of amethyst (and other varieties of quartz) to 2·42 in the case of the diamond. This is one of their most valuable properties, which renders them extremely brilliant when properly cut. But so far as this property goes, successful imitation is not impossible. Modern research in optical glass, as is well known, has rendered possible the production of glasses having a refractive index as high as 1·96; the refractive index of every stone except the diamond can therefore be matched.

All such glasses are, however, amorphous, and therefore of necessity single refracting, whereas the natural gem stones are crystalline, and with the exception of the few species which crystallise in the cubic system (such as the diamond, spinel and garnet), possess considerable double refraction. This renders coloured specimens in many cases strongly pleochroic, a property which enhances their beauty and which is entirely lacking in the glass "paste" manufactured to imitate them.

But the brilliancy consequent upon such optical properties is not the only essential feature of precious stones—along with it we have a very great degree of durability, due to a combination of chemical stability and extreme hardness, and it is more particularly in this direction that imitation gems are inefficient, for it is practically impossible to produce this *combination* of properties in any other material.

It is well established, for instance, that the refractive power of glass can only be increased beyond a certain point at the expense of its hardness and chemical stability, and optical glass, having an index of refraction at all approximating to the figure above mentioned (1·96), is so soft as to readily scratch, and so unstable that it becomes corroded on exposure to the atmosphere for a comparatively short time.

It is true that the hardness and stability can be increased to a certain extent by proper adjustment of the composition and by careful thermal treatment, but the best combination that can be obtained is a hardness of close upon 7 with a refractive index of 1·6.

With the growth of scientific knowledge, therefore, attention has been more and more concentrated on the production by artificial means of stones identical in composition with those of natural occurrence, more particularly as research in this direction, apart from the economic point of view hitherto considered, has considerable scientific value, as tending to elucidate the conditions governing the natural formation of minerals.

The first point to be considered in attacking this problem is the composition of the stone, as it is obvious that, other things being equal, the possibilities of success are greater with one of simple than one of comparatively complicated composition. One also has to consider, however, the economic aspect—it is not much use (except for scientific purposes) devoting time and ingenuity to the production of an artificial stone when the natural one is so common that the cost of the two would be practically identical.

Taking these two points in conjunction, and confining our attention for the moment to the transparent stones as summarised in the accompanying table, the diamond appears to offer the most promising field for attack, and corundum comes next, and we find that the main attempts at artificial production centre round these species. From the point of view of composition alone, quartz is the most simple, but it is so common in nature as to render artificial production scarcely worth while. The aluminate group offers some attraction, but the artificial production of crystalline silicates on a large scale is a very difficult problem, and, with the exception of the emerald, the stones comprised in this group are so freely distributed in nature as to render their artificial production a matter of scientific rather than industrial interest.

COMPOSITION OF THE PRINCIPAL PRECIOUS STONES.

	SPECIES.	VARIETY.	COMPOSITION.
ELEMENT	Diamond	—	Carbon.
OXIDES.	Corundum.	Ruby. Sapphire Oriental Amethyst, etc.	Oxide of Aluminium.
	Quartz	Rock Crystal. Amethyst Cairngorm, etc.	Silica.
ALUMINATES	Spinel	Balas Ruby, etc.	Magnesium Aluminate
	Chrysoberyl	Cymophane Alexandrite	Beryllium Aluminate.
SILICATES.	Beryl	Emerald Aquamarine	Beryllium Aluminium Silicate.
	Garne	Hessonite.	Calcium Aluminium Silicate.
		Pyrope	Magnesium Aluminium Silicate.
		Almandine	Iron Aluminium Silicate.
		Demantoid, etc.	Calcium Iron Silicate.
	Olivene	(Peridot)	Magnesium Iron Silicate.
	Sphene	—	Calcium Titanium Silicate.
	Spodumene	(Kunzite)	Lithium Aluminium Silicate.
	Topaz	—	Aluminium Hydroxy Fluo-Silicate.
	Tourmaline	—	Complex Alkali-Lime-Alumina Silicate.
	Zircon	Jargoon Hyacinth	Zirconium Silicate.
	Turquoise	—	Hydrous Aluminium Phosphate.
	Opal	—	Hydrous Silica.
	Pearl	—	Calcium Carbonate.

The Diamond.

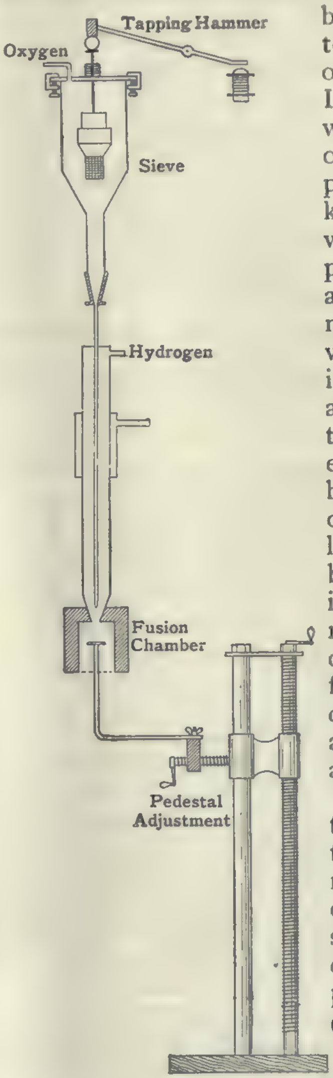

FIG. 1.

The production of artificial diamonds by Moisson and others is so well known that it need only be referred to. Some fifteen years ago, on the occasion of a visit to Paris, I had the privilege of witnessing the production of these diamonds, prepared, as all the world knows, by saturating iron with carbon at the temperature of the electric arc, and plunging the molten mass into cold water. The mass of iron is then dissolved in acid and the residue subjected to a laborious process of extraction, the diamonds being picked out by aid of the microscope. The largest diamond that has been produced in this way is barely visible to the naked eye, however, and commercially, we are as far from being able to produce artificial diamonds as in the days of the alchemists.

It is, perhaps, a bold thing to say that no such thing as an artificial diamond will ever be placed on the market, but one can safely assert that so far as our knowledge stands at present it is impracticable.

Corundum.

To pass on to corundum, the problem of its artificial production is very much simplified by the fact that its composition is oxide of aluminium, and alumina—which is, therefore, its amorphous equivalent—fuses to a liquid under ordinary atmospheric pressure at a temperature of about 1,800° C., and being the only stable oxide of a strongly basic metal, it can be heated in air without any change.

The chief problem to be faced, therefore, is that of attaining the necessary temperature, and it is not surprising that fused alumina was produced as a scientific curiosity as far back as the commencement of the nineteenth century, by means of the then newly invented oxy-hydrogen blowpipe. But this method of production was not developed for some considerable time, as it was supposed that the beads of fused alumina produced in this way must be amorphous—it was not realised until many years later that they were really identical in all their properties with natural crystalline corundum.

The earlier experimenters in the production of artificial gems worked in another direction, the crystallisation of the alumina from solution; they were unable to obtain products of commercial utility, because although they succeeded in obtaining crystalline alumina, it was produced under conditions which resulted in the formation of a mass of small crystals, almost microscopic in size. Moreover, the form of these crystals was that of the hexagonal plate which is the fundamental form of corundum, and such a form would be useless for cutting even when of considerable area, owing to its thinness.

It was not until the nature of the fused alumina produced by the blowpipe was realised that artificial rubies and sapphires became a commercial possibility, and it was not until 1904 that Verneuil brought the process to perfection when he hit on the extremely ingenious idea of introducing the raw material *through the blowpipe*, and thus placing it on the support automatically. The diagram (Fig. 1) shows the principle of his apparatus. The blowpipe is arranged vertically over a small insulated chamber containing the support on which the mass is to be built up. The oxygen tube communicates at its upper extremity with a funnel-shaped hopper. In this hopper is suspended a small sieve filled with the raw material, which is rhythmically shaken by means of a small hammer actuated by an electro-magnet or cam. Each time the hammer taps the support of the sieve, causing it to vibrate, a small quantity of the powder falls through into the tube below, and, carried along by the gas, passes out at its lower extremity into the zone of flame, where it is immediately raised to the fusion point, and falls as a melted globule on to the support below.

As seen in the diagram, this support is arranged with a screw adjustment, so that as the mass of corundum is gradually built up by the constant addition of fresh globules the surface is kept at a constant level, and the portion already formed removed from the zone of heating so as to allow it to stiffen. When the apparatus is first started the blowpipe is adjusted so as to give a comparatively cool flame, and the powder is admitted slowly. By this means a small "stalk" is formed, which insulates the mass from the support and prevents the fusion of the latter. When this has been formed the full pressure of the blowpipe is put on and the rate of admission increased, with the consequent formation of a "boule," as it is termed, having the shape of a pear as illustrated in Fig. 2.

With this apparatus a boule weighing some twenty to thirty carats, and capable of yielding two cut stones of about six carats each, can be prepared in about half an hour almost automatically, a single operator being able to control several machines. The boules, on cooling, very often split in half in the direction of their growth, as will be noticed later on, and this is a convenience rather than otherwise, as the resulting shape can be cut to greater advantage.

In the first instance "reconstructed" rubies were produced by this method, the raw material being chips and cuttings of natural ruby reduced to powder. More commonly nowadays, however, the corundum is produced direct from amorphous alumina, the raw material being ammonium alum, which decomposes on reaching the flame. Stones made by this direct method are generally known as "synthetic," as distinct from "reconstructed."

The "synthetic" corundum produced in this way, if pure ammonium alum is used, is, of course, colourless, and can be used as artificial white sapphire. If a small proportion of chrome alum is added, the resulting stones are rubies, and other colours may be produced in the same way. For a long time all attempts to reproduce the fine blue of the sapphire failed, because following the apparent analogy of silicates, cobalt was invariably employed as the colouring agent. This, however, does not readily form an aluminate in the same way that it does a silicate, and, in consequence, it is impossible to produce a satisfactory colouration in the corundum by its means. A year or so ago, however, the problem of producing synthetic sapphire was finally solved by the use of titanium oxide, a very unexpected result, considering the chemical position of this element. With this last advance the artificial production of the corundum gem-stone may be considered to be completely solved, and such stones can now be obtained in every variety or colour, from pure white to ruby and sapphire, and they are produced commercially in very large numbers, at prices ranging from one to ten shillings a carat, according to colour, quality and size.

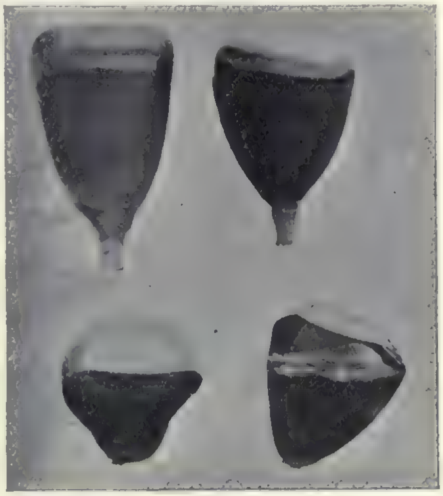

FIG. 2.

Whatever may be their economic importance, a very much debated question, there can be no doubt as to the scientific interest of this group of artificial gems. In the first place it is a matter of some interest that a mass of fused material formed in this way should not only be crystalline but possess all the characteristics of a single crystal.

(*To be continued.*)

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

RECENT DEVELOPMENTS IN THE CHEMICAL PURIFICATION OF DRINKING WATER.

By S. Rideal, D.Sc., F.I.C.

Considering that one of the first duties demanded, and also frequently one of the greatest difficulties, of a water management has been the provision of a supply which shall be physically acceptable to their consumers in regard to clearness and colour, engineers have naturally devoted themselves to questions of subsidence and filtration, but have met with serious failings at times in the mechanical treatment of various waters. Some of the faults have been inherent to the water, and others accessory.

Such an inherent fault as a high salinity is a very great difficulty in some parts of the world, where water which is not brackish is almost impossible to attain, and as there is no practicable method of purifying it short of distillation it is fortunate that such liquids, if otherwise pure, are not specially unwholesome. Where the sodium chloride, as in most cases of marine origin, is accompanied by a considerable amount of magnesium sulphate, if we remove the magnesia by precipitation with soda we produce an equivalent amount of sodium sulphate, with perhaps an improvement in taste, but a doubtful hygienic advantage.

The inherent fault of undue hardness, of extreme importance from an industrial point of view, has been shown to have much less significance with regard to health. At the same time it has been proved that such waters are much improved organically by a proper process of softening, and one of the advances in this direction was indicated in my last article.

Other very serious defects of certain waters are lead solvency and iron solvency. The former has been generally overcome by treatment of the water with calcium carbonate or lime. The latter causes grave inconvenience in various districts, and in the United States is dignified by the name of the "red plague," on account of the water in so many towns being rendered unbearably ferruginous. Investigations have proved that waters of very varying chemical composition are liable to this evil and that it is connected with the growth of certain organisms, especially of the genus *Crenothrix*, therefore the fault may be said to be rather accessory than inherent.

There can be no doubt as to the accessory nature of the odours and tastes which are often caused by the growth of algæ and other organisms in reservoirs and conduits. Covering the reservoirs to exclude light discourages a large number of species, but is rather favourable to others which are not innocuous, and moreover is only applicable on a limited scale. It has been found necessary to resort in a large number of cases to sterilising agents, and further work has shown that their use, carried out carefully and regularly as a system, could render a water free from inconveniences as well as hygienically safe. In regard to algæ and infusoria, sulphate of copper has long been known to be effective, but, on account of its poisonous nature being feared, has been mainly limited to emergencies. Hypochlorites and ozone have both come into extended use in various parts of the world with an experience that their expense is not unreasonable, and that they solve the old difficulties and dangers.

Some years ago I found that a sodium hypochlorite solution was effective in preventing green growth in waters, and I have made a number of trials with waters containing various species of algæ, mainly with a view to comparing the inhibitive action of hypochlorite with that of copper. The employment of the latter in the form of sulphate had met with success in different countries when used in the proportion of one part per million down to as low as one in fifty millions, and an important point was that the worst tastes and odours were generally the most susceptible. The cost was very small, but some outlay was occasioned by the systematic testing of the product for freedom from traces of the metal, after the minute amount used is precipitated as a basic salt by the natural carbonate of lime of the water, the coagulating effect usually leaving the liquid very clear and bright and free from copper.

Although the objection to the use of copper in this way was mainly a sentimental one, it was felt that hypochlorite would be preferable if it was effective, and such proved to be the case. I found that green and brown algal growths and objectionable microscopic animals could be prevented from developing by the use of small quantities of solutions containing available chlorine. The different species require for their arrest varying amounts of chlorine, confervæ appearing the most susceptible, as available chlorine just in excess of that immediately consumed by the water, although disappearing in a few hours, inhibited confervoid growth for some weeks. Desmids were slightly more resistant, and in my experiments required the addition of some 0·5 part per million in excess of that immediately consumed by the water. Diatoms required about one part per million of chlorine in excess. The addition of one part of copper sulphate per million was not equal to that of 1·2 parts per million (0·2 in excess) of available chlorine.

The useful re-agents and processes have been hitherto too much regarded as rivals and in competition with one another, and it has been reserved for a South African engineer, Mr. Donald Leitch, who has designed and carried out the Klip Valley waterworks for supplying the large Johannesburg and Rand district, to employ several of the processes in conjunction. It is singular that it has not earlier been seen in analogy with medicine that specifics that were not incompatible or antagonistic could be valuable adjutants to one another. In case of injurious organisms, for example, if any of them escaped the action of one remedy they might be dealt with by another, not to speak of the likelihood that several agents might enhance each other's energy. The result of Mr. Leitch's work seems to have been most efficient, with a very moderate expense. His report just published describes the works supplying a population of nearly 370,000, included in seven municipal areas covering 365 square miles, the daily quantity of water pumped lying between 7 and 8 million gallons. The source is mainly from shafts and boreholes in the dolomite, with some surface water and springs. The hardness is generally high, averaging 18 to 19 parts per 100,000, of which 9½ to 10 are said to be carbonate of lime and 7½ to 8 carbonate of magnesia. The supplies were often turbid, and sometimes contained much iron, amounting frequently to 2 parts per million, which encouraged the growth of "weed" (presumably crenothrix and other algæ) in the mains. The water is softened by lime down to a mean of 14 parts per 100,000, and the growth of "weed" is checked by the addition of about 1 part in 3 millions of sulphate of copper. The ferrous iron contained is then oxidised and precipitated by falling through perforated plates on to beds of clinkers. This arrangement has been in use for about 18 months and answers its purpose satisfactorily; with a weekly cleaning it reduces the iron to between 0·2 and 0·3 parts per million, which gives no further trouble. The total cost of the removal of iron in this way, including all capital charges, is about 5/6 per million gallons.

After these operations the chemical quality is found to be excellent and the bacterial content low, rarely more than 10 organisms per c.c. growing at 37°C. But during the summer or wet season, *B.coli* is often present; sometimes only 1 in 10 c.c., but occasionally more. The Johannesburg medical officer, Dr. Chas. Porter, therefore recommended the use of a small quantity of chloride of lime for sterilisation and this was adopted with success, the amount used being 7½ to 15 lbs. per million gallons, equal to ·25 to ·5 parts per million of available chlorine, while the total cost is about 6/3 per million gallons. *B.coli* is absent from the treated water, and the total bacteria are generally reduced to one or two per c.c. During the winter this sterilisation is discontinued for the dolomite supply, but continued for the wells in town whose surroundings are more suspicious. The total cost of the works has been about £900,000, and the entire cost of the supply and treatment is given as 2s. per 1,000 gallons. The water is sold by meter, and the whole scheme is a commendable example of thoroughness in treatment.

OILS, FATS, AND MILK PRODUCTS.

By E. RICHARDS BOLTON and CECIL REVIS.

SOME interesting experiments have been carried out by Dunlap and Gilbert (*Journ. Amer. Chem. Soc.*, 1911, xxxiii., 1787) with castor oil seeds, which have been freed from fat, seeming to show conclusively that the enzyme contained in these seeds is able to synthesise fats from an emulsion of glycerin and oleic acid. As the presence of a fat-splitting enzyme in castor oil seed is quite well known, and its powers technically employed, these experiments evidently furnish another example of the reversibility of enzyme action.

In our last article we drew attention to the dangers which may arise from the use of poisonous fats for edible purposes, if sufficient care is not taken in their examination. In this connection the results of the examination of a number of fats of the genus Hydnocarpus by Lendrich and others (*Zeit, Unters, Nahr. Genussm*, 1911, xxii., 441) are particularly interesting. They point out that these fats contain chaulmoogric and hydnocarpic acids, to which acids the poisonous nature of these fats is due. A certain number of experiments were carried out on dogs, the administration of these fats causing severe vomiting, and often more serious symptoms.

Some figures have also been published on the composition of Para rubber seed oil by Pickles and Hayworth (*Analyst*, 1911, xxxvi., 491). These authors draw attention to the fact that the oil dries to a hard varnish in about 12 days, and that in the liquid fatty acids, which make up 86% of the total present, there is nearly 51% of linolic acid. Their findings therefore, emphasise the point which we have already hinted at, that this oil in the future will form an excellent substitute for linseed oil. By the ordinary observer the smell of the oil will be considered almost identical with that of linseed oil. As we have just mentioned the presence of fat-splitting enzymes, it may be noted that these seeds furnish a striking example of the technical difficulties which often arise in connection with seeds containing such enzymes, in, that, unless properly handled, considerable hydrolysis of the oil takes place during manufacture or shipment. A sample in the hands of the authors, which was commercially prepared with proper precautions, shows however such a low acidity that it is evident that this difficulty may be obviated by proper handling.

The annual report of the directors of the North of England Protecting and Indemnity Association is of particular interest to all those concerned in the handling of oil bearing nuts, etc. The carelessness displayed in the shipment of these is well known, and often leads to considerable deterioration of the product for the reasons we have just mentioned. It is just in such matters as these that the foreigner gets ahead of the conservative Englishman, by taking care to have responsible agents on the spot, both during loading and unloading, and reaping thereby considerable advantage.

A method for the rapid extraction of oil from feeding stuffs for purposes of mill control, as recommended by Neumann (*Chem. Zeit.*, 1911, xxxv., 1025) using trichlorethylene, has been carefully examined by Grimme (*Chem. Rev. Fett. Ind.*, 1912, xix., 15), particularly for cotton seed meal. The latter author has compared the results obtained, using ether, chloroform carbon tetrachloride, dichlorethylene, trichlorethylene, and some other solvents. He arrives at the conclusion that only trichlorethylene, as originally recommended by Neumann, leads to results which compare favourably with the official ether extraction method. The results are somewhat remarkable, more particularly as it has been found that, when trichlorethylene is commercially employed for the extraction of oleaginous meals, a considerable quantity of colouring matter is invariably removed at the same time, a result which is in sharp distinction to that obtained with "benzine." As in the experiments described by Grimme there was considerable variation in the percentage of fat extracted with the various solvents employed, the objection may be raised that the agreement between ether extraction and that of trichlorethylene may be perhaps the result of compensating effects, such as the extraction of a certain amount of colouring matter making up for a slight deficiency in the fat. It will therefore be necessary to ascertain that the agreement holds good for all types of cake before displacing the generally accepted ether extraction method, which is really no more tedious of application. Both accuracy and consistency of results in these matters are very necessary commercially, and it will probably be inadvisable to depart from the recognised method for such purposes. The method, however, should prove of some advantage where proper laboratory accommodation is not available.

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SCIENTIFIC METHOD IN CELLULOSE INVESTIGATION.

By C. F. Cross.

The numerical standards of physical science have their humbler beginnings, and are elevated to the peerage of transcendental quantities as the result of what we may shortly describe as convergent verifications. Thus water is a "standard" substance in more than one department of science: but we should know but little of our standard if we were confined to observations on fluid water and if temperature were the only measure of "heat."

In this order of idea we think it is time to adopt a definite standard or normal measure of cellulose: a basis of numerical expression of its more characteristic properties.

It is clear that such a standard must originate from within: we can only compare cellulose with itself, one form of cellulose with another. And in respect of what? Mainly in regard to (1) chemical inertness or non-reactivity; (2) structural characteristics.

The former we may define in terms of (a) resistance to hydrolysis, alkaline and acid; (b) resistance to oxidants, alkaline and acid; and the latter in terms of tensile strength and elongation at rupture.

To avoid a lengthened exposé of matters familiar to all students of the subject, we take it as admitted that the quantitative measurements available for the exact definition of these characteristics are:—

Weight, i.e., variations of weight:

Cupric-reduction (Fehling's solution): and of secondary importance, certain affinities for colouring matters.

On the physical and mechanical side determination of breaking strain and elongation, for which we are in the main limited to observations upon textile yarns.

Assuming as admitted that the nearest approximation to a normal cellulose is a cotton cellulose purified (and incidentally bleached) by processes of alkaline hydrolysis and oxidation, and that a calico printer's "madder-bleached" cloth is the typical representative; we may briefly set out its claims to be taken as the normal standard.

It loses no weight when treated with solutions of sodium hydrate (17·5% NaOH) under "mercerising" conditions; it is not oxidised by Fehling's solution: its structural qualities are at least on the level of the original untreated cellulose.

As a matter of common observation, many forms of bleached cotton show marked inferiority in terms of the above tests, that is, they contain alkali-soluble forms of cellulose, they reduce alkaline cupric oxide, and are below the standard of tensile quality.

But this inferiority holds for cellulose of reputed "purity," such as paper-makers' "rag" celluloses, bleached wastes (cotton) as supplied for manufacture of nitro-celluloses, and even for a large range of ordinary bleached textiles.

At the moment, we are not concerned with these, but rather with the products or derivatives known as hydro-celluloses, oxy-celluloses, resulting from the action of alkalis, acids, and oxidants upon the normal cellulose. Now the literature of this section of cellulose chemistry is sufficient evidence of the necessity of applying general co-ordinating principles which we take to be these: (1) the products in question are not chemical individuals, but necessarily mixtures, and (2) should be defined in terms of the processes which produce them.

This result would follow from the adoption of the root method of science, which is to quantify the relation of effect to cause.

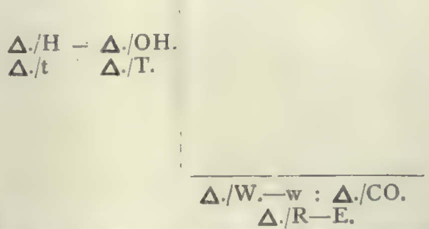
Thus in this particular case, and considering the hydrolytic changes:—We have to connect

Conditions of Action: { Concentration of reagent Alkali$^{(OH')}$ or Acid$^{(H')}$
Temperature$^{(t)}$ and Time$^{(T)}$

with

Modificatian of Constitution and Structure in terms of { *Weight changes* in reaction, and by analysis of products—(W, w). *CuO reduction* (measure of CO groups set free.) (CO.)
Tensile strength and Elasticity. (R–E).

It is clear that the simplest expression of such relation is the familiar diagram



Conditions being expressed as ordinates, and effects (measured on the products) as abscissæ.

On this basis of comparison a given product, *e.g.*, hydro-cellulose, would be defined by three curves which would at once picture the course of chemical and structural disintegration of the aggregate.

But as a preliminary the "normal cellulose" would be similarly defined, giving us the fundamental constants for which we have as yet only intuitive approximations.

Chemists would be wearied by an elaboration of this theme. It is suggested to younger students and schools of technology that a really fundamental contribution of systematic research awaits willing workers; a mass of material in the form of records already existing and merely requiring re-editing on the plan here suggested, with complementary observations in order to give any required degree of definition or accuracy to the curves.

This suggested procedure is pre-determined for us by the methods of the starch chemists. It is evident that there would have been little progress in this field if chemists had confined themselves to observations on individual compounds, or mixtures assumed to be individuals, representing the residues of transformations—under hydrolysis—of the original starch complex. The analogies of cellulose with starch are sufficiently definite to suggest that we should endeavour in this way to give an equally full account of the breakdown of the cellulose complex.

In the complementary region of investigations that is the study of the synthetical derivatives of cellulose—nitrates, acetates, benzoates, xanthates—there is an implied recognition in all the published records that these compounds are not to be studied as chemical individuals of invariable constitution, but represent the conditions of the re-action under which they are formed; that is, with invariability as regards stoichiometrical ratios, there is essential variability in the constitution and properties of a particular compound regarded as an aggregate. Hence these compounds can only be fully defined, each as a series. Perhaps the major problem in this field is the apparent continuity of cellulose re-actions—how far this is true of, or actual for, the re-acting unit?

Even this problem may be solved by methods which maintain the re-acting groups *and* aggregate under inclusive observation.

UNIVERSITIES AND COLLEGES.

THE CHEMICAL LABORATORY OF THE UNIVERSITY OF CAMBRIDGE.

By WILLIAM J. SELL, M.A., Sc.D., F.R.S., Lecturer in Chemistry in the University of Cambridge.

THE Chair of Chemistry in the University of Cambridge, which was founded in 1702, is now occupied by Professor W. J. Pope, M.A., LL.D., F.R.S. The present Jacksonian Professor of Natural Experimental Philosophy, Sir James Dewar, M.A., LL.D., F.R.S., has shared with the Professors of Chemistry in the teaching and research work since his election in 1875.

The present Chemical Laboratory, which replaces an older one, is a four-storied building, with a frontage of 275 feet on Pembroke Street, and occupies a ground space of about 3,000 square yards. The front of the older portion of the building is seen on the left-hand side of the accompanying photograph; this part was erected in 1887, under the direction of the former Professor of Chemistry, Dr. G. D. Liveing, F.R.S. (1861-1908). A considerable extension was opened in 1908, and is depicted on the right-hand side of the photograph. In consequence of the rapid growth of the natural sciences in Cambridge the Chemical Laboratory, which accommodates over 500 workers, is now practically full, and further extensions will soon become inevitable.

Prof. W. J. POPE, M.A., LL.D., F.R.S.

The funds available for the construction of University buildings in Cambridge are, in general, very limited in amount, and cannot be regarded as adequate for the purpose they have to serve. Although substantial chemical buildings have been provided, and although the internal fittings have been so devised as to leave little to be desired in connection with their suitability, over-elaboration and the use of costly or highly ornamental materials have always been avoided for reasons of economy. And in view of the rapidity with which laboratory furniture and equipment become obsolete, no compunction is felt in replacing the fittings of any of the laboratories immediately some more modern and serviceable arrangement can be planned and financed; this policy finds continual and active application.

The principal rooms in the laboratory consist of a suite of three laboratories for general inorganic and elementary organic work on the ground floor, three laboratories for advanced general and organic work on the floors above, a laboratory for advanced analytical work, and a set of five lecture theatres, of which the two larger provide seating accommodation for audiences of 150 and 250 respectively. The simpler operations of Physical Chemistry are performed in one large room, whilst a number of smaller rooms are available for special branches of the subject, such as polarimetry, spectroscopy, photomicrography and other photographic operations, etc. Until recently the Agricultural Department was housed in the Chemical Laboratory; this has now been moved to a large special building, and a suite of five rooms thus set free has been equipped as a metallurgical laboratory. The necessary facilities and appliances for practising the ordinary assay operations, electric furnace and high temperature work in general, metallography and electro-chemistry, are thus available. A number of rooms are set apart as private research laboratories for members of the staff and post-graduate students, and for the accommodation of balances, a library of periodical literature, etc.

GENERAL LABORATORY.

After an undergraduate has taken the Previous Examination several principal avenues exist by which he may pass to the B.A. Degree in the University of Cambridge. The first, which leads to the ordinary degree, demands residence during three years, attendance on certain prescribed courses of tuition, and success at the corresponding preliminary and final examinations. Candidates for the ordinary degree may sit for their final examination in Elementary Chemistry, but this option is exercised by but few—some thirty per annum. The second mode of proceeding to a degree consists in taking one of the Tripos examinations for Honours, after residence during two or three years; the candidate devotes himself to the study of three, four or five of the subjects prescribed within a particular Tripos, and in due course presents himself for examination. Some two hundred candidates thus sit annually for Part I. of the Natural Sciences Tripos, and, of these, the major portion have worked in the Chemical Laboratory. The student, having taken Part I. of the Natural Sciences Tripos, may now specialise in one particular branch of science, and at the end of three or four years from matriculation present himself for examination in Part II. of the Tripos in that science. It is also permissible for a student, who has already taken an honours science degree at some approved University, to proceed to a degree in Cambridge, on presentation of a dissertation embodying research work carried on during two years of residence; for the prosecution of the latter course the Cambridge laboratory offers special advantages. Further, the concentration of effort consequent on residence, the wide range of the science embraced by a large staff of teachers, and an ample provision of necessary appliances and facilities, have resulted in a considerable output of research work in many branches of Chemistry. The importance attached to original work is emphasised by the annual award of a prize of £50 for the best piece of research work in Chemistry carried out in the University.

That so few undergraduates who have studied any science subject take the ordinary degree in the University is certainly unfortunate for the country at large. It cannot, however, be doubted that the selective process resulting from the sharp demarcation between the candidates for the ordinary and the honours degree leads, on the whole, to the retention of the intellectually stronger for the higher work, and tends to lessen waste of time and effort in connection with the inevitable weeding-out of the fit from the unfit.

The terms during which the ordinary routine of lecture and laboratory work are carried on in Cambridge are short; the academic year consists of two terms of about eight and one of about seven weeks. Within these periods it is possible to deliver all the lectures desirable, and to perform the more formal part of the necessary laboratory operations in Chemistry. The rest of the year can thus be devoted to the purely practical chemical work which cannot be carried out within a specific number of hours to be defined beforehand. The Chemical Laboratory is thus open for work during about ten months of the year, although the customary courses of formal lectures are only delivered during about six months. It cannot be denied that the Cambridge system of limiting the period assigned to formal routine teaching in the lecture room, and devoting the time thus set free to laboratory work and original research, is a very healthy one. The student of either of the great practical natural sciences is required nowadays to attend far more lectures than are good for him; he is very apt to acquire the view that his science is to be learnt wholly in the lecture room, and that the broken intervals of laboratory instruction available have been provided mainly for the purpose of assisting him to memorise the vast masses of learning hurled at him by the lecturers. The most efficient mode of dispelling this fallacy, and of bringing home to the student the all-important fact that Chemistry is a practical science, demanding the acquisition of great manipulative skill, is by the ample provision of long periods within which laboratory work can be carried on without interruption throughout the day. During the periods the mental staleness induced by attendance at nine or twelve lectures per week becomes dissipated, and a renewed zest for the absorption of theoretical knowledge is acquired; the lecture room takes its true place in the student's survey as an auxiliary to the laboratory.

ORGANIC LABORATORY.

During late years a rapid change has been observed in the type of career adopted by graduates who have specialised in Chemistry in the University. Formerly the greater proportion of these became teachers, and many of them are now occupying responsible positions in other Universities. Within recent years, however, it has become unusual for a graduate who has taken Chemistry in Part II. of the Tripos to take up educational work, and posts are obtained by nearly all of them in connection with the chemical industries.

LABORATORY OF PHYSICAL CHEMISTRY.

The reason for this change is not immediately obvious. The industrial demand for scientifically, well-trained chemists, has undoubtedly increased enormously during the last ten years, but this demand has been amply catered for so far as numbers are concerned by the technical schools throughout the country. For many years past the older Universities have realised the importance, and have strained every effort in the promotion of scientific studies; in the main, however they have confined themselves to the provision of a

FURNACE ROOM OF METALLURGICAL LABORATORY.

sound and broad training in scientific method, and in the purely scientific aspects of each specific science, relegating to the background a secondary position to the purely technical aspects. The view which has been taken is, in fact, that pure science is best learnt at the University, and the technical operations of applied science in the works. The technical school, on the other hand, frequently adopts the view that both can be well taught side by side in the school. The historians of a later century will decide which of the two views is correct. Parenthetically, it may be noted that the utility of co-operative effort, which is of prime importance in all industrial work, is nowhere so forcibly inculcated to the student as in a resident University. As the source of the demand cannot be disregarded in the provision of the supply, efforts have been made in Cambridge to bring home to the student that the laboratory operations which he performs will have to be translated later into works practice. In the Chemical Laboratory sufficient engineering and mechanical equipment is provided and utilised, and in the shape of a power station distributing electric current of various voltages throughout the building, liquid air and carbon dioxide refrigerating plant, filter presses, vacuum plant, and the resources of a mechanic's workshop, to furnish some idea of the nature of industrial chemical operations.

The Chemical Laboratory.

The short duration of the academic year, the large number of students to be dealt with, and the desirability that the courses of study and research should embrace as wide a range as possible, demand a highly perfect organisation in the work, and a considerable catholicity in the selection of teachers. In Cambridge the more elementary aspects of inorganic and general Chemistry are dealt with by the Professor of Chemistry and Mr. F. W. Dootson, M.A., D.Sc.; the Jacksonian Professor, Sir James Dewar, LL.D., F.R.S., lectures on elementary organic Chemistry. The Goldsmiths' Reader in Metallurgy, Mr. C. T. Heycock, M.A., F.R.S., lectures on metallurgy and descriptive inorganic Chemistry; and lectures on advanced inorganic and on general and physical Chemistry are delivered by Dr. W. J. Sell, F.R.S., and Dr. H. J. H. Fenton, F.R.S.; Mr. S. Ruhemann, M.A., Ph.D., and Mr. H. O. Jones, M.A., D.Sc., lecture on advanced organic Chemistry, and the chemical side of hygiene and public health is dealt with by Mr. J. E. Purvis, M.A.

NOTES OF MEETINGS, &c.

THE CHEMICAL SOCIETY.

March 7th and 21st.—Ordinary Meetings.

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SOCIETY OF CHEMICAL INDUSTRY.

London Section:—March 4th.—"The Photographic Process," by Dr. C. E. Kenneth Mees.

Liverpool Section:—March 13th. — "Catalytic Action of Unsaturated Acids," by Mr. Shaw.

BIOCHEMICAL CLUB.

March 2nd.—Annual General Meeting at University College.

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ROYAL INSTITUTION OF GREAT BRITAIN.

March 2nd, 9th, 16th, 23rd, 30th.—Professor Sir J. J. Thomson, "Molecular Physics."

March 15th.—"Origin of Radium," by F. Soddy.

THE PHYSICS AND CHEMISTRY OF COLLOIDS

By EMIL HATSCHEK.

CHAPTER II. (*Continued.*)

IN this manner the sizes of the particles in many sols, especially of the metals, have been calculated, and these agree within reasonable limits with values obtained by Bechhold from experiments with ultra-filters.

With direct sunlight particles of 5 $\mu\mu$ dia. can still be seen. In many sols, however, particularly organic ones, no particles can be seen even in those circumstances, but only a diffuse light. This may be due either to their small size, or else their having a refractive index very near that of the liquid. Particles visible in the microscope are generally described as microns; those which can be made visible by the ultra-microscope as submicrons, and those which cannot be resolved even by the latter method as amicrons.

The apparatus just described is the most perfect one for the observation of ultra-microscopic particles, and the only one which permits measurements to be made. As it is rather costly and requires very powerful illumination, a number of simpler devices have been introduced, in which the light is projected through the film of liquid parallel with the axis of the microscope, but certain arrangements are made to prevent direct light from entering the instrument. The principle of all these appliances is the same, and will be readily understood by reference to Fig. 5, which shows a section of the "paraboloid condenser" made by Carl Zeiss. The condenser P is a paraboloid of revolution, of glass or rock crystal, bounded by two parallel planes. Parallel rays entering the condenser are, as is well known, reflected into the focus of the parabola, and the top of the condenser is so adjusted that this focus falls on the surface of the slide O, which is of a definite thickness. A central stop B covers the bottom of the paraboloid, and permits only such rays to pass as will, after reflection, strike the surface under an angle greater than the critical angle, so that they would be totally reflected by the top of the condenser, if in contact with air. By placing water or cedar oil between this surface and the slide—as indicated by the black line I—the light passes through the slide and any liquid placed on it, but is totally reflected at the cover glass placed on the liquid. If, however, the latter contains particles, light is dispersed from them—as indicated by the dotted lines—which can enter the microscope and form an image.

This and similar condensers can be fitted to any microscope, and can be used for rendering visible submicrons, a Nernst lamp or incandescent gas mantle being quite sufficient for illumination. Measurements are not possible, as the volume of liquid cannot be accurately determined.

From the foregoing it appears that colloidal solutions in many cases contain particles which can be made visible by appropriate means, and whose size can be determined. The sizes are still very considerably larger than the limit values for the size of various molecules arrived at by numerous investigators employing a great variety of methods.

In this presence of particles of sizes greatly exceeding molecular dimensions, must be sought one of the fundamental differences between colloidal and true solution. To emphasise this, we shall in future employ the terminology now in general use, by calling the colloidally dissolved substance the "disperse" and the solvent the "continuous" phase, terms which explain themselves and form a constant reminder of the fact, that colloidal solutions are systems of two phases.

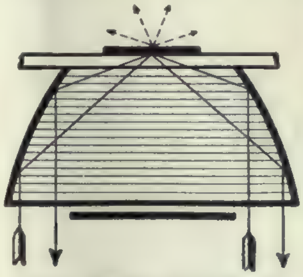


FIG. 5—SECTION OF PARABOLOID CONDENSER, SHOWING PATH OF RAYS.

A knowledge of these sizes, however, does not, by itself, explain the striking differences between various types of colloids, nor does it form a basis of classification. These differences are particularly marked as regards the behaviour towards electrolytes, which precipitate one type—the inorganic sols—even in small quantities, while they have little effect on many organic colloids—such as gelatine, agar, etc.—even in large quantities. A division into "lyophobic" and "lyophilic" colloids—*i.e.*, such as remain reluctantly and such as remain freely in solution—has been based on this difference by Perrin and Freundlich. This is, however, merely descriptive, and the classification adopted by Wolfgang Ostwald appears for many reasons preferable. This takes for its basis another, equally marked, difference between various types of colloids, the difference in the viscosities of their sols, and will be discussed in the next chapter.

CHAPTER III.

THE reader is no doubt aware of what is understood, in a general way, by the viscosity of a liquid: the resistance offered to shearing, stirring or the flow through a capillary tube. If a liquid is contained between two parallel plates and one of these is moved with a constant velocity in its own plane, a certain force is required, which depends on the velocity, the surface and distance of the two plates, and of course on the nature and temperature of the liquid. This gives us the definition of the "viscosity coefficient" at any temperature: the force required to move a plate of unit surface separated from another plate of the same size by a layer of liquid of unit thickness, at unit velocity. Such coefficients for many liquids, expressed in gramme—centimetre—second units, can be found in Landolt and Börnstein's tables.

As regards colloidal solutions, they divide themselves into two classes, if the increase of viscosity, compared with that of the solvent or continuous phase, is taken as the basis of classification. One class, the metal and sulphide sols in particular, shows a viscosity only very slightly higher than that of water. The other, which comprises principally the organic colloids, such as albumin, gelatine, gum arabic, agar, etc., shows a very marked increase of viscosity, even if the percentage of dissolved matter is small. To explain this difference some of the earlier investigators in this field, more especially Quincke, resorted to reasoning by analogy, based on the known behaviour of systems containing the disperse phase in a much coarser form than do the sols. It is a fact familiar to everybody who has stirred up finely divided solid matter, such as a precipitate of calcium carbonate or barium sulphate, with water, that even 20 or 30 % do not offer a very great resistance to stirring, *i.e.*, do not cause a great increase of viscosity. On the other hand, it is equally well known that systems of two liquids insoluble in each other, generally called emulsions, can under certain circumstances show enormous increase in viscosity compared with either phase. Various pharmaceutical preparations coming under this head are familar to everyone; extreme cases are represented by some emulsions used as lubricants, and by Pickering's emulsions with 99% of oil in 1% of soap solution, which could be cut into cubes.

Applying these considerations to sols, we are led to the conclusion—now generally accepted—that in those which show a low viscosity the disperse phase is present as solid particles, while in the sols with high viscosity the disperse phase is liquid. An albumin sol, for instance, would consist of a dilute solution of albumin, in which are dispersed drops or globules consisting of a much more concentrated solution. This conception is certainly not an easy one, and will receive further discussion when we arrive at the detailed consideration of the class of colloids to which it applies, but it is the only one which explains all their peculiarities. Nor does it rest any longer on the analogies set forth, but is strongly supported by mathematical investigations, undertaken independently and by entirely different methods, by A. Einstein and by the author during the past two years. These show, that the presence of *solid* particles in a liquid can only raise the viscosity by small amounts simply proportional to the volume of solid matter present; when a few per cent. of —apparently—solid matter like agar raise the viscosity some hundred times, it follows that the disperse phase cannot be solid.

Systems consisting of solid particles of microscopic size distributed through a liquid are generally called suspensions, while those having two liquid phases are called emulsions. Wolfgang Ostwald accordingly calls the sols resembling the former "Suspensoids," and the sols which resemble the latter, in showing markedly high viscosities, "Emulsoids," which terminology we shall adopt in future. These two classes coincide to a very great extent with the "lyophobic" and "lyophilic" colloids.

The suspensoids show a much more uniform behaviour towards various influences than the emulsoids, and will, therefore, be considered first. We are now in the possession of two distinct data: we know the approximate size of the particles in a large number of sols, and we have concluded that they are solid. The next step is to co-ordinate these two factors by examining the behaviour of small particles suspended in a liquid, and especially how this changes when their size decreases to ultra-microscopic dimensions.

It was shown by Stokes in 1850 that a *small* sphere falling in a liquid soon assumes a constant velocity, which is given by a formula that has been used in an enormous number of most important investigations, and has led to numerous results of great value. If we call

r the radius of the particle,
s the specific gravity of the same,
s′ the specific gravity of the liquid,
η the viscosity coefficient of the latter,
g the gravity constant,

the constant velocity of the particle is:—

$$V = \frac{2r^2 (s-s')g.}{9\eta}$$

It is obvious that the difference (s—s′) may be positive, zero or negative, that is the particle may sink, remain stationary or rise if its specific gravity is greater, equal to, or smaller than that of the liquid. It is also obvious that the velocity, in whichever direction, is inversely proportional to the viscosity of the liquid: a particle of a given size and weight will sink several hundred times faster in water than in castor oil. The point which, in the present connection, interests us most is, that the velocity is—other things being equal—proportional to the square of the radius.

To fix ideas it will be useful to consider an example in figures, say a gold particle of 1 μ radius or 2 μ diamenter. Introducing the proper values (all in cm., gr. and seconds), *viz.*, $r = 10^4$, $s = 19{\cdot}3$, s' (water) $= 1$, $g = 980$, η at 20° = 0·01, we find the velocity of the particle about *0·04 mm.* per second, or 2·4 mm. per minute.

This is, of course, a considerable speed, and means, in other words, that such a suspension of gold particles would clear at the rate of 2·4 mm. per min. from the top, and would be clear to a depth of about 14 cm. after one hour.

Assuming now the radius to be 1/100 of that just considered, or 10 , which is the size of the particles in a red gold sol as determined by many measurements, the velocity would be 1/10,000 of that calculated. This makes it only *0·0144 mm.* per hour, or about 10 mm in one month. With particles of lower specific gravity the rate of settling would, of course, be still lower, *e.g.*, with a sp. gr. of 3 it would be a little over *one mm.* per month.

This little calculation shows us, that with particles sufficiently small and not much heavier than the liquid, a suspension may appear very stable and take a very long time to show any marked clearing. At the same time, we already are familiar with one property of sols—their liability to undergo irreversible transformation—which precludes our accepting mere smallness of particles as a sufficient explanation of the stability of many sols. A suspension is reversible: when it has settled, however long the process may take, it can be shaken up again, and this may be repeated indefinitely. This is not possible with a sol like the metallic sols; when this has coagulated, the gel cannot by mere shaking be transformed back into the original sol. We are therefore forced to the conclusion that the particles are subject to other influences besides those of gravity and viscosity. Investigation has shown this reasoning to be correct, inasmuch as the particles are in violent motion, and are also electrically charged.

The motion of the particles in a sol is the most striking feature in the ultra-microscopic image. It is, however, visible even with much larger particles and ordinary illumination, and was first observed as far back as 1827 by Dr. Brown, a botanist, after whom it is called the Brownian movement.

(To be continued.)

PERSONAL AND OTHER NOTES.

Professor William Odling, M.A., M.B., F.R.S., F.I.C., Waynflete Professor of Chemistry at the University of Oxford, has resigned his appointment.

The Glasgow and West of Scotland Technical College, will be known in future as the Royal Technical College, Glasgow, by command of His Majesty the King.

Sir Archibald Geikie, President of the British Association, was the principal guest at the Pepys Commemorative Dinner at Magdalene College, on the 21st ult.

The *Times* referring to the late Lord Lister, said:—"He may be called the great life-saver. More than ten years ago it was computed that he had saved more human lives than all the wars of the Nineteenth Century have sacrificed, and the record has been steadily rolling up ever since."

Institute of Chemistry Lectures.

MR. CHARLES F. CROSS, B.Sc., F.I.C., delivered his second lecture on "Cellulose," before the Institute of Chemistry, at University College, London, on Friday, 23rd February, Professor J. Norman Collie, LL.D., F.R.S., presiding.

The Celluloses as structural colloids are the end terms of a series of carbohydrates, exhibiting analogous properties in varying degrees, and the lecturer selected for demonstration of the series, types of colloids of industrial importance.

Starch, and its derivative *Feculose,* extensively used in the production of surfaced "Art" papers; *Tragasol,* obtained from the endosperm of leguminous seeds, and also extensively used as a "gum" in textile finishes, leather dressing, etc.; *Cutiloid,* a new Colloid obtained by chemical reaction from Tragasol, and used as a tanning agent and in paper sizing; *Japanese Isinglass,* obtained from certain *Algæ,* and exported from Japan to the extent of £200,000 per annum for consumption, chiefly in China, as a food stuff. These were compared with Cellulose, hydrated and dissolved to structureless solutions and reverting to hydrated massive forms, or films.

The papermakers' beating process was considered as a mechanical method of producing hydration effects, and the principle of the new "Jackson" beater was expounded, with specimens of its effects.

Questions of minute structure and dimensions, being inseparable from Cellulose, the importance of complementary histological observations and research is to be impressed upon young students. It was shown that typical reactions of Cellulose, can be studied in terms of surface dimensions of the reacting Cellulose, also that approximate calculations can be made of surface dimensions of solids of natural, and therefore irregular or variable minute structure—*e.g.*, cotton.

In conclusion, the question of the world's supply of Cellulose, past, present, and future, was considered, and it was also pointed out that in the cellulose industries, mechanical and chemical, we are guilty of waste or destruction of substance, and therefore of value, on a colossal scale, much larger than the historical instances of the wastes of glycerin and coal distillation products, happily long since terminated.

Apart from the waste of wood, and wood by-products attention was specially drawn to megasse, or sugar cane refuse, and cotton seed hull fibre, and the positive prospects of their utilisation.

The lecture was illustrated by specimens.

BATTERSEA POLYTECHNIC.

E. Frankland Armstrong, D.Sc., Ph.D., F.C.G.I., will deliver the remaining lectures on "Enzymes" on March 6th, 13th, 20th, and 27th, 1912, at 7.45 p.m., respectively. Admission is free. The full course is as follows:—

Lecture 3.—Specific enzymes:—Sucroclasts, Diastase, Zymase, Lipase, Proteoclasts, Urease.
Lecture 4.—Nature and composition of enzymes. Behaviour as Colloids. Animal enzymes.
Lecture 5.—Plant enzymes. Function in plant and animal metabolism.
Lecture 6.—Oxydases and plant respiration. Relation of enzymes to problems of heredity.

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER II.

PRELIMINARY SURVEY AND SELECTION OF SUBJECT MATTER.

"Zeal without knowledge is like expedition to a man in the dark."—*Newton.*

THE choice of subject matter will be influenced by the special qualifications of the investigator. A natural bent on the part of the student may generally be followed. Considerations connected with his future career, which may already be settled in direction, must also play a part in any selection. In the latter case the nature of the research and its object may be more easily determined. In the past, organic chemistry has claimed great attention. Speaking generally, there is a fashion in this as in most things. To-day, the attention of investigators is directed to many other branches, such as those dealing with investigations of the abnormal properties of colloids, catalysis, or electro-chemical investigation.

It is necessary to start with a definite aim, and to select a problem for investigation which seems to offer advantage in its solution. Investigation may take the shape of the study of a known reaction under new conditions, the confirmation of some law, or the search for a new one. A mere hunt after new compounds, on a plan equivalent to an addition, or subtraction, sum is to be deprecated. For this, coupled with the recognition of the substances produced, possibly represents investigation in its lowest terms. At the same time the general usefulness of such work may, in the early stages of research, be accepted, where more important work is not available; and this criticism must not be taken as applying to the definite isolation and analysis of natural products. Research on elementary lines may open out in unexpected directions, and disclose conditions which in themselves indicate the possibility of more important work. Its value in developing skill and resource is of a higher order than mere text-book reactions, where observation is the only factor involved.

The beginner need not be discouraged by comparatively simple conditions of working. These represent the working conditions of some of the greatest investigations of the past. Those of Griess, dealing with the action of nitrous acid on amines, led to an extraordinary development in organic chemistry. The study of this reaction, and the compounds produced by coupling, has given rise to theoretical and practical results of the highest order.

When the extent of the field of modern chemical investigation in its various branches is realised, it should not be a difficult task for the student to select a subject for consideration, and further investigation, and to make sure that any research arising out of the same shall have a definite aim from its inception. Specific instruction cannot be given in this matter. This belongs to the practical side of the question, but the suggestions made in these notes may be generally considered when a choice has not already been made.

The nature of the research must necessarily be considered in relation to the facilities which are available for carrying it out. Circumstances, and the position of the investigator, may therefore determine to a great extent the nature of the research undertaken; and whether it will involve problems in pure or applied chemistry.

The importance of what has been described as residual phenomena should be carefully remembered. Sir W. Crookes has pointed out that these "may lead a man of disciplined mind and finished manipulative skill to the discovery of new elements, or new laws, and even new forces. Upon undrilled men these possibilities are simply thrown away. They are of the highest moment to the student."

Care must be taken to distinguish phenomena which only seem to point to apparent laws. No attempt can be made in these cases to draw general conclusions from them. At the same time a real exception may overturn the strongest theory; but interfering circumstances must be looked for very carefully when dealing with observations of this nature. It is often by comparing such exceptions that important discoveries are made. The methods of leading investigators should be studied. These at once indicate the extreme care which must be exercised in the conduct of research.

When it is fully realised that discovery is the result of a definite search, the value of the simplest piece of original work, correctly carried out, will be apparent, especially when it is considered as a training for more important research. The investigator must realise the progressive nature of his work.

Preliminary Search for Past Records.—This must be undertaken in some detail before the actual research is started. The student must have definite knowledge of any work which has previously been undertaken in a similar direction. The source of available information under present conditions may be divided into four sections:—

(1) Text-books and Dictionaries.
(2) Journals of Chemical and other Societies.
(3) Technical and Semi-Technical Journals.
(4) Patent Literature.

Text-books are more useful for general work and in the preliminary stage of this research; but there is a growing tendency for these to be devoted to detail in special directions, and where this is the case, they become of more importance to the investigator. Descriptions of a general nature should always be supplemented by a reference to the original communication, whenever this is possible. The details to be found there are often of first importance. They naturally cannot be included in text-books, where the compilers of such works have not, as a rule, the same object before them as the investigator.

Such works as Beilstein, or Dammer in his *Anorganisch Chemie und Chem. Technologie*, or Moissan's *Chimie Minerale* may be studied with advantage. The growing tendency to give reference to the original papers is a satisfactory one.

Reference to Journals.—It is always necessary to refer to any journals dealing specially with the subject in hand. Many of these which have come into being in recent years are confined to certain branches or subsections of the original science.

Thus it would be necessary for an investigator dealing with the chemistry of Colloids to carefully search the *Zeitschrift für Chemie und Industrie der Kolloide*, and when dealing with Tannins and their action, it would be necessary to refer to *Collegium*, the "official" journal connected with that branch of industrial research. In the case of dyeing, the *Revue Générale des Matières Colorantes*, the *Farber Zeitung*, and the *Journal of the Society of Dyers and Colourists* might be searched for definite information.

The International Catalogue of Science and the Indexes of the Royal Society's Proceedings should be carefully considered. Reference to a certain paper or communication will often by cross references open out a wide field for further information. The student must in this way make a special search for previous work. The leading journals to be consulted may perhaps be taken as those abstracted for the *Journal of the Chemical Society* and for the *Society of Chemical Industry*, respectively.

Résumés such as the monographs in Ahren's "Sammlung" are of special significance.

The preliminary search may also include the annual reports issued by the Chemical Society. For instance, the 1910 number contains articles covering the general progress in General and Physical Chemistry, Inorganic Chemistry, Physiological Chemistry, Agricultural Chemistry, Organic Chemistry, Stereochemistry, Analytical Chemistry, Vegetable Physiology, Mineralogical Chemistry, and Radioactivity. The general publications of the German and American Chemical Societies must also be consulted.

Besides the general papers appearing in the journals, the abstracts should be carefully considered. This search is facilitated when the collected index system is adopted, and which from its usefulness is destined to come into general use. The system of abstracting adopted by the leading journals has improved, and is now so complete that it may be used in the preliminary stage of an investigation with increased confidence. According to the latest information no fewer than one hundred and fifty journals are abstracted by the Society of Chemical Industry for their journal.

Patent Literature.—In some cases an important source of information will be found in the current patent literature as published in this country, Germany, France and U.S.A., respectively. Copies of these patents may be seen at the Patent Office Library in Southampton Buildings, Chancery Lane, E.C., which is open from 10 to 10 o'clock daily. Many of the technical journals, such as that of the Society of Chemical Industry, abstract these patents in increasing numbers.

No likely source of information concerning past literature should be overlooked. This search may be regarded as part of the investigation, and the beginner must pay all attention to this matter, as it is one of first importance. It will reduce the possibility of an investigation being merely a repetition of previously published work to a minimum. The present advanced state of chemical investigation increases the value, and need of, this preliminary work.

When once the nature, or direction of, the research is determined, any references obtained in this manner should be carefully indexed, and a short abstract prepared dealing with their probable influence on the work under consideration.

This search, in conjunction with the selection of subject matter, may be regarded as the first step in the normal path of an investigation. These may be secured concurrently in some cases. The importance of method must be fully realised at this early stage, and should never be lost sight of until the research is completed and recorded in detail.

The beginner will naturally start work on a modest scale. The results to be looked for at this early stage are personal experience, training in actual manipulation, and an insight into the work of others as translated into actual practice. Minute attention to detail will bring with it method. The simplest piece of original investigation successfully carried out will bring with it confidence, which will develop, and give ever increasing value to such work. The results obtained by an experienced investigator are to no small extent determined by the nature of his previous training.

Faraday, when reviewing his work up to the year 1832, divided it into good, moderate and bad. He valued the results on a personal basis, "because of the utility they have been to me, and none more than the bad, in pointing out the faults it became me to watch and avoid" (Tyndall, "Faraday as a Discoverer," page 38).

The student must never be discouraged by the time required to obtain experience and confidence. Faraday suggested that "it required twenty years of work to make a man in physical science, the previous period being one of infancy."

Investigation conducted on proper lines develops in a natural way, and with it the experience and power of the investigator. From the simplest research a new line of investigation may open out, and important results may be ultimately obtained. Tyndall considered that the real vocation of an investigator "consists of the incessant marriage of induction and deduction."

Personal Qualifications.—These are varied in their nature, and of great importance. They can only be considered in a general way. Curiosity, patience, critical power and industry are among them. How far these can be developed or even created by training is a matter for conjecture; but even where these are possessed, they must still be developed to their maximum.

The power of taking full advantage of observation, of being able to appreciate the value and significance of abnormal conditions as they arise, can only come with long experience and practice. It has been well said, that "every fact and every discovery casts a light beyond itself, and the extent to which this light is perceived depends upon the man. Training can certainly develop this natural faculty of observation and apply it to certain ends, even if it cannot supply it.

This power of observation should, therefore, be trained to its highest degree. Combined with the faculty of imagination, it is always exhibited by investigators who have made their mark in scientific research.

Manipulative Skill.—This can only be secured by extended experience in the operations involved in such investigations. It is here that the practical training of the college course may be such an important factor. Manipulative skill is of more value than elaboration of apparatus. Cavendish in a simple way obtained results indicating the proportion of oxygen in the air, which were practically identical with those obtained years afterwards by Bunsen and Regnault, when working with all the elaboration of apparatus then available.

At the same time there are natural limits to each specific method of working, and neither of these methods led to the isolation of the rarer constituents now known to be present in the air, although Cavendish's work clearly pointed to their existence.

The fact that Cavendish conducted the simplest operations on a quantitative basis may indicate the care required in successful investigation. He never prepared hydrogen without recording the amount of iron, or zinc, taken and the volume of gas generated; even when there was no immediate object for these observations. Faraday was equally careful, always repeating the experiments of others. "I am never able to make a fact my own without seeing it," he said. Also, "that he could trust a fact, but always cross-examine an assertion."

Many investigators find it advantageous to visualise in some way, the reactions involved in a research in its different stages. They are curious enough to form a mental picture, which may represent the nature of the reaction under consideration. Apart from any real significance in the effect produced, the plan is undoubtedly a good one. It may be observed that this power of picture-making has been carried so far in some branches of research, that it seems to be the beginning and end of many investigations. Such endeavours must not be classed with the Kindergarten. They represent the romance of science, and symbolise advance from stage to stage. At the same time, they indicate the natural limitations of our methods of investigation.

As in learning a language, it is necessary to think in the same before any real advance can be achieved, so in research a similar condition applies; the symbols used, crude as they may be, are a direct aid towards this end. It is often the chief aim of an investigator to secure this result. In its effect it may carry him over many a rough road. There may then be some consolation to the investigator in a non-successful issue to an investigation; for when this is represented in its true light, and occurs under satisfactory conditions of working, it does not so much represent personal failure, as the limits of investigation for the time being.

The use of elaborate apparatus is under some conditions essential. The latter may be necessary to the success of the investigation. Under ordinary circumstances this condition will not apply, and the aim of the investigator should be to work under as simple conditions as are compatible with success.

Effect of Introduction of Instruments of Precision.—This has brought about far-reaching results. Lavoisier made use of the balance in 1778, and his investigations conducted with its aid exploded the philogeston theory, as a natural and inevitable consequence. The working out of some new apparatus often follows the discovery of some new scientific fact. It represents the practical application of the same. The invention of an instrument like the spectroscope, or the elaboration of the balance to meet the needs of chemical research, may almost be regarded as equivalent to the extension of one of the senses. The worker therefore endeavours to make use of such aids in his research. Under modern conditions this can generally be accomplished, as most of the modern colleges possess an adequate supply of these instruments, and they are present in many private laboratories.

Cost of Experimenting.—In the aggregate this is very large. The compilation by the Royal Society of mere titles and publication of the more important scientific investigations, cost nearly £10,000 up to the year 1879. It has been remarked that the cost of the researches themselves would amount to several millions, and that "these were made entirely at the expense of the investigators themselves, nearly all of whom were men of limited means."

Under modern conditions, very large sums are supplied in some cases by commercial firms, for the conduct of research. The preliminary work connected with the production of artificial indigo is said to have accounted for an expenditure of nearly a million sterling. In many directions large sums have been spent in investigating, on scientific lines, problems which may lead to an industrial application.

Investigations of this order often entail the use of complicated methods. Past experience has demonstrated that such operations, when brought to a successful issue, may have a value, which is represented by adequate financial gain.

This result is increasingly influencing the general progress of research. Many of the larger industrial laboratories dealing with such problems equal in their equipment, if they do not excel, those of many of the leading universities.

Research conducted under such conditions and to such ends, entails details of an exacting nature, and demands manipulative skill and knowledge of a high order.

The conduct of such investigations offers a promising field to the investigator who has the necessary training, and knowledge of the methods to be employed. He must cultivate a scientific habit of thought, and combine this with a sound business insight into the working of industrial operations, and a practical knowledge of the results obtained, and aimed at, under such a system.

Generally speaking the investigator must have his mind stored with the chief facts and principles of science, he must be able to imagine, invent, manipulate, observe, compare, and reason. (*Gore.*) With such a stock in trade the investigator can hardly fail to meet with success in the ever-widening field of original or applied research.

(*To be continued.*)

Scientific Investigation.—Mr. Runciman recently stated that "A sum of about £2,000 a year would be available to carry on work at Rothamsted in connection with soil problems and plant nutrition. Cambridge University had undertaken work which would be confined almost entirely to animal nutrition, problems of animal breeding, and Mendelism. For research work in regard to swine fever £1,000 had been spent. The same applied to anthrax. He would have to ask in the future for an amount running into several thousand pounds for research in connection with foot and mouth disease."

Separation and Grading of Solids suspended in Liquids.—W. T. Gee recently gave particulars before the Society of Arts of a new process depending upon the passage of the liquid through a rapidly rotating drum. The solids are deposited upon a removable lining of the same, by centrifugal force, the clear liquid passing on. Whilst the drum is rotating a current of water is passed through it from one end to the other, with the result that the solids are deposited in graded order, the heaviest particles settling near the inlet and the lightest at the further end.

CURRENT LEGAL TOPICS.

SAMPLES IN CASES OF APPLICATIONS FOR PATENTS FOR CHEMICAL INVENTIONS.

By W. Jago, F.I.C.

According to the Patent Act of 1907, the Comptroller-General is entitled, under certain circumstances, to require the deposit of samples illustrative of a chemical invention. This is enacted by Subsection 5 of Section 2, which reads as follows:

"Where the invention in respect of which an Application is made is a chemical invention, such typical samples and specimens as may be prescribed shall, if in any particular case the Comptroller considers it desirable so to require, be furnished before the acceptance of the Complete Specification."

Although the Act has now been in existence for several years, the important question of the extent of the range of samples the Comptroller may require to be furnished, has only just been raised before the Law Officer, sitting as a Court of Appeal from the Comptroller-General. The Law Officer delivered a considered judgment, which clears up certain points concerning this subject which hitherto have been doubtful.

Two appeals were heard together.

In the first case the invention was of two processes by which analogous series of products were obtained. In illustration of the first process two samples were furnished, and one in illustration of the second. The Patent Office demanded seven additional samples. The claims covered hundreds of substances.

In the second case the first part of the invention was the manufacture of a certain class of intermediate products, and next two processes for the conversion of any one of the aforesaid intermediate products into safranine colouring matters by combination with any number of one or other of two classes of compounds which are generically described. Here nine samples were furnished, four of intermediate products and five of colours. The claims in this case covered "thousands" of bodies. The specification referred to certain other compounds, of which it stated that they "have been found particularly useful," and of these, three samples were required.

In each case the applicants were in a position to furnish the extra samples, although at some expense; in order to raise the point this particular action was fought.

It will be noticed that in both actions there were series or groups of bodies which are alleged to have a certain reaction in common, and it is just in such cases that any difficulties generally arise.

The Law Officer laid stress on the fact that "typical" samples only are to be demanded, which he defined as meaning "not a whole series of samples sufficient to exhaust every possible variation and modification embraced by the claims, but a limited number of illustrative examples, so chosen as to stand fairly as types of what is claimed." The object is to prevent the granting of mere blocking Patents, while on the other hand, allowing the inventor the benefit of the generality of his discovery if it really has as wide an application as is claimed for it.

In dealing further with the legal aspect of class reactions, the Law Officer laid down certain principles which should afford considerable guidance to those who may be about to patent chemical inventions. Thus, in a true case of class reactions, a chemist would be warranted in believing that all the members of the class will give the same reaction. If he is the first to have discovered this reaction, he is certainly entitled to claim its application to the whole of the members of that class.

The validity of such a claim must evidently depend on whether or not in fact the whole of the members of the class are amenable to the reaction in question. Should they not happen to be, the whole claim is bad as claiming too much. For this reason group reactions should be verified along the complete line of members before the whole are claimed.

The Law Officer very pertinently indicated that of a class some members might be so energetic that the reaction would occur so violently as to decompose the bodies, or, on the other hand, they may be so inert that the reaction would proceed too sluggishly to be successful. In such a case the inventor must restrict his claims to those in which the reaction really does succeed. Or "possibly the inventor has erroneously supposed his discovery to be a class reaction, whereas in truth it is an individual peculiarity of the particular substance with which he has experimented."

The object, of course, of requiring samples, is to ascertain whether the width of the claim is justified, so as to "protect the public from the mischief of unwarrantably wide claims based on theoretic reasoning, when the actual reaction has not been sufficiently tested. None but an expert can gauge the cases in which the claims include fields that require independent experimental verification. The Comptroller's powers must be exercised with caution, in order not unduly to thwart claims representing the application of a scientific deduction to a wide field, and his demands must be for samples that are typical, not for samples that are exhaustive."

The effect of the decision is to uphold the authority of the Patent Office in its discretion in the way of range of samples to be demanded, subject to the rules laid down for guidance in the above referred to decision.

NEW METHODS OF ANALYSIS.

SEPARATION OF LIQUID FROM SOLID FATTY ACIDS.

By S. FACHINI and W. DORTA.

IN a previous note published in the *Journal* of the Italian Chemical Society, Rome Section, 1910, "On a research on pea-nut oil in olive and other oils," we proposed the use of acetone for the qualitative separation of liquid fatty acids from solid fatty acids. We have now extended our research to saturated and unsaturated fatty acids and their alkaline salts, and examined their action toward acetone of different concentration.

The results of the researches thus undertaken can be classified as follows:—

1. Separation qualitative and quantitative of liquid from solid fatty acids;
2. Behaviour of sodium and potassium salts of liquid and solid fatty acids toward acetone;
3. Research on solid fatty acids: qualitative separation of stearic and palmitic acids from myristic acid and other acids of lower molecular weight.

Separation of Liquid from Solid Fatty Acids.

Solid fatty acids are almost insoluble in acetone at ordinary temperatures. They can easily be dissolved at higher temperatures in this way, a precipitation of stearic and palmitic fatty acids occurs also at the ordinary temperature, while most of the fatty acids with lower molecular weight, such as myristic and lauric acids, will remain in solution.

The precipitation of solid fatty acids by pure acetone is only partially accomplished in presence of liquid fatty acids; the majority of solid fatty acids precipitate from the pure acetone solution when their temperature is reduced to O°C. On this fact the separation proposed in the preceding note is based.

Experiments undertaken with a mixture of pure fatty acids, such as palmitic, stearic and oleic, have demonstrated that the separation of solid fatty acids from oleic acid at the temperature of O°C. can be considered as practically quantitative.

This result was accomplished by dissolving 10 grams of the three acids mixed in several proportions in 100 cc. of acetone (95%).

The solution was then cooled in iced water, kept there about an hour, and now and then submitted to agitation.

The solid fatty acids quickly deposit as minute crystals: these are then filtered through the filter, proposed by Fleisher, and kept at O°C., they are washed with small portions of acetone brought to the same temperature, keeping apart the acetone employed in washing.

The fatty acids so obtained and dried on a plate of porous porcelain have the appearance of beautiful bright laminæ, quite colourless, but non-transparent. Iodine number of oleic acid, obtained from the filtered portion, was 87·5 to 88·2, which shows that the separation of the two groups of acids is satisfactory. We must note that the method proposed does not aim at obtaining a quantitative separation (as in Warrentrapp's method with lead salts) of liquid fatty acids from solid fatty acids, but simply that of separating in a possibly pure state the two groups of acids in order to investigate them. Several experiments dealing with fatty acids derived from non-drying oils and vegetable and animal fats, composed essentially of palmitic, stearic and oleic acids, have fully confirmed the results obtained with pure fatty acids.

Olive oil gave liquid fatty acids with iodine number 89·6; solid fatty acids with iodine number 2·3.

The iodine number of liquid fatty acids obtained according to the lead salts method was 90·0. From tallow, liquid fatty acids were obtained with iodine number 88·5 to 89·0: the iodine number of solid fatty acids was insignificant.

The separation is satisfactory also for the mixture of fatty acids derived from semi-drying oils: we examined tomato-seed oil and Canadian grape-seed oil.

The liquid fatty acids of the former gave as iodine number 140—141, those of the latter 150·9. Iodine numbers of the liquid fatty acids of these two oils, separated according to the lead salts method, resulted for tomato-seed oil 141·5, for Canadian grape-seed oil 149·9.

For the qualitative preparation of rather large quantities of solid fatty acids we adopted the following process:

Working upon a concrete fat, the mixture of fatty acids, obtained as explained before, is placed in a porcelain capsule, and mixed carefully with a pestle with an equal quantity of acetone (95%), cooled to O°C.

By the aid of a spatula we place the mixture on a funnel provided with a filter, connected with an air pump and maintained at O°C.

The solvent is removed, then washed with small quantities of acetone at O°C., until the fatty acids appear perfectly colourless.

These can be eventually recrystallised from acetone and then are dried on a porcelain porous plate. The solid fatty acids remained in the filtrate, and eventually in the washing waters, which may consist of palmitic and myristic acids, are precipitated by potassium hydroxide, as described below.

Action of Sodium and Potassium Salts of Liquid and Solid Fatty Acids in the presence of Acetone.

Alkaline salts of palmitic, stearic, and myristic fatty acids are almost insoluble in pure anhydrous acetone: their solubility gradually increases with dilution and temperature. The sodium salts require a diluted acetone for their separation: sodium stearate, palmitate and myristate are dissolved at the boiling point in proportion of about 1 gram per 100 grams of acetone (80%); their solutions do not crystallise in acetone, but are thrown out in a semi-liquid condition.

The potassium salts exhibit a very different and quite characteristic action; potassium stearate and palmitate are easily soluble in boiling acetone, in proportion of 1 gram to 100 grams of acetone (90% by volume). During the cooling process, at the temperature of about 46°C., potassium stearate crystallises in the shape of characteristic thin needles grouped in the form of radial clusters; potassium palmitate crystallises, at the temperature of about 28—30°C. in minute crystals; potassium myristate, in the same condition of dilution, does not precipitate when cooled to 12°C.: from acetone (95%), for instance, it crystallises near 30°C. in small needles, smaller than those of stearic acid, grouped together in small clusters.

Potassium salts of oleic and linoleic fatty acids (liquid), in the same conditions of dilution and temperature, are not precipitated. They precipitate at the ordinary temperature from their solutions in anhydrous acetone.

On these reactions we suggest a method for the separation of stearic and palmitic acids from liquid fatty acids, and a method for the quantitative separation of stearic and palmitic fatty acids from myristic and other fatty acids of lower molecular weight.

The Fatty Acids of Olive Oil.

Ten grams of olive oil were saponified, with alcoholic potash. The soapy solution was put in a separation funnel and shaken with ethyl ether in order to remove all unsaponifiable substances; from the aqueous solution, the fatty acids were separated by the addition of diluted sulphuric acid, collected on a filter and washed, as usual, until any mineral acid reaction disappeared.

The fatty acids, melted and filtered, were dissolved in 90 cc. of acetone by heating to the boiling point: a solution of 10 cc. normal caustic potash was added to the clear solution, a quantity more than enough to precipitate the solid fatty acids contained in olive oil. (Liquid oils at the ordinary temperature do not generally contain over 20% solid fatty acids.) During the cooling process the crystallisation begins about 32—35°C. when solid fatty acids precipitate under shape of thin needles grouped in clusters. When the solution reached the temperature of 15°C. it was filtered through a dry filter, collecting the filtrate in a separation funnel.

To the clear solution was added an equal quantity of water and the whole shaken with ethyl ether: the solvent was eliminated by a current of carbon dioxide from the ethereal stratum previously washed, and the resulting fatty acids submitted immediately to iodine number determination, which for the liquid fatty acids obtained according to the described method was 98·2.

Iodine number of liquid fatty acids obtained according to the described method 98·2.

Iodine number of liquid fatty acids obtained from the same oil according to the lead salts method was 98·5.

To ascertain if a portion of solid fatty acids in the olive oil was left, as potassium salt, in the liquid fatty acids, the solution from the etherial stratum containing the potassium salts of liquid fatty acids was acidified with dilute sulphuric acid and shaken in a separating funnel with ethyl ether, the solvent was eliminated from the etherial stratum, and the acid fats dried in a current of carbonic anhydride, submitted to iodine number determination, which gave 95·2.

From this it appears that the separation of liquid fatty acids from solid fatty acids is quantitative in the case of non-drying oils, when these do not contain saturated fatty acids with molecular weight less than palmitic acid.

The slightly lower iodine number observed in the non-saturated fatty acids obtained from potassium salts, may be attributed to a more prolonged exposure to air.

The solid fatty acids collected on the filter and washed with anhydrous acetone, aided by a filter pump, and then dried on a porcelain porous plate, treated with water, acidified with sulphuric acid and washed, gave hardly any trace of unsaturated fatty acids. Iodine no. (average) =3·8.

A semi-drying oil also, tomato-seed oil, was examined. Liquid fatty acids obtained from this oil, by the method just now described, gave as a result an Iodine no. 140·6. Iodine number obtained by the lead salts method was 141·5.

It is claimed that this new process will allow of the complete study of the fatty acids entering into the composition of a given oil or fat, by a fractional precipitation of saturated and non-saturated fatty acids as described.

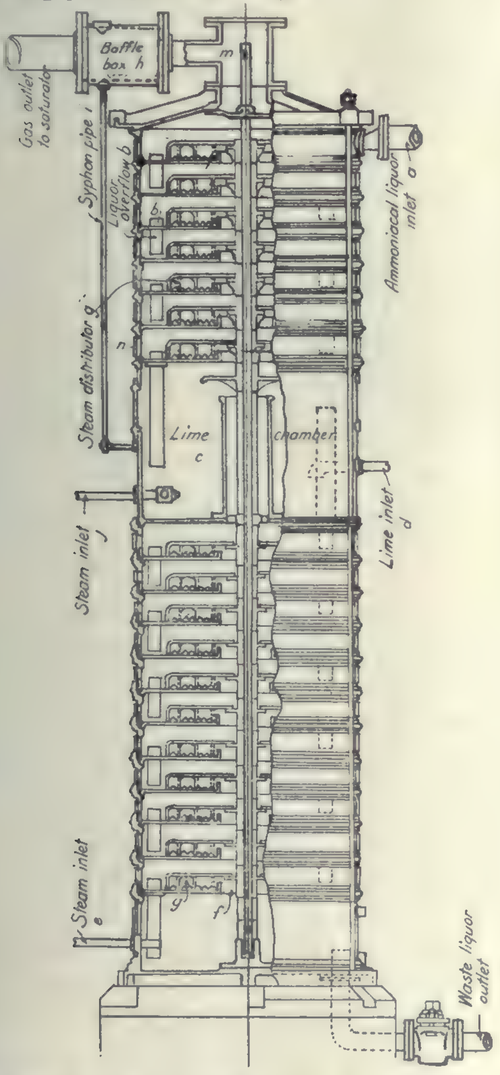
REVIEWS OF BOOKS.

"THE MANUFACTURE OF SULPHATE of AMMONIA."

By G. T. Calvert. JOHN ALLEN & CO., 1911. Pages 153 + vi, including Index. Chaps. II. with Appendix. 97 Illustrations. Price 7s. 6d. net.

THE general particulars dealing with the manufacture of sulphate of ammonia as practised in gas works are dealt with in this volume, illustrations being given of many typical plants used to-day for its manufacture in this country.

The analysis of such materials and the raw materials from which it is produced is also dealt with. The accompanying illustration gives some idea as to the way this subject is treated. The book should be of value to those interested in this increasingly important subject.



"MICROBIOLOGY."

Edited by C. E. Marshall. J. & A. CHURCHILL, London, 1912. Pages 724+ix., including Index. Chaps. 47, with 128 Illustrations. Price 10s. 6d. net.

THIS book is intended primarily for agricultural and domestic science students, but it is likely to have a wider field before it. The editor has been assisted in his task by nineteen contributors, who occupy important positions in American Universities and Colleges. The work is divided into seven divisions, and covers such subjects as morphology and culture of micro-organisms, their physiology, applied microbiology, including the microbiology of the air, water and sewage, soil, fixation of atmospheric nitrogen, etc. The microbiology of milk and milk products, and of the food industries, including the important question of food preservation, production of alcohol, vinegar and other fermented products, is then considered. The manufacture of vaccines, anti-toxins, etc., is treated at some length. Sections dealing with diseases of plants and animals, and the methods of infection, immunity and susceptibility, complete the list of subjects dealt with.

A perusal of the pages of this book cannot fail to indicate the rapid advance which has followed the investigation on scientific lines of bacterial and mould life; and this work, with its many illustrations, is calculated to bring this point before the student in a satisfactory manner.

NITRO-CELLULOSE INDUSTRY.

By Edward Worden. CONSTABLE & CO., LTD., London, 1911. Vols. I. and II. Price 42s.

It is impossible within the space of this review, to do justice to this important work, extending as it does to 1,147 pages of subject matter and 91 pages of index. The author has produced a book which must necessarily remain a standard work for some years to come. It deals with cellulose, cellulose nitrates, the nitration process, and then naturally with the solvents used in actual practice, giving special reference to amyl alcohol, and amyl acetate.

The recent substitutes for camphor, as well as the so-called synthetic or artificial camphor, are dealt with at length.

The many uses of such solutions of nitrocellulose are then discussed in detail, and particulars given as to their actual solution on a manufacturing scale. Enamels, lacquers and bronzing fluids are described; also the manufacture of imitation leather and fur, and the waterproofing of textiles of such solutions, special attention being given to pyroxylin-coated leathers, which are so largely used to-day.

The manufacture of artificial silk is considered not only in the case of the rapidly disappearing nitro-cellulose process, but in the viscose, cupro-ammonium, and the other less important ones.

Celluloid is treated in extraordinary detail, and the use of these materials in photography is also considered at great length; gun cotton, and the explosive cellulose nitrates are dealt with in the same exhaustive manner.

The subject of cellulose acetates is dealt with, also viscose, and its products, and uses. The book ends with a full description of the denaturing of ethyl alcohol under American conditions, and an appendix.

The book is crowded with references, and the name index is of extraordinary length. There can be no doubt but that this work is the most important one ever written on this subject, and both the author and publisher are to be congratulated on its production. It sets a standard for text-books of this nature, which will be difficult to approach, and almost impossible to exceed.

HIGHER MATHEMATICS FOR CHEMICAL STUDENTS. By J. R. Partington. METHUEN & Co., London, 1911. Chapters XIII. and Appendices, with 44 Diagrams. Price 5s.

This book is of interest to the chemical student, and is written in a form which can easily be followed. The object of the mathematical treatment of a subject like chemistry is well laid down, for, although the mechanism of a process is the ultimate goal of experiment, this generally lies outside the range of the senses. Some consequence of the mechanism is therefore thought out, and tested by mathematical reasoning, and in this way the hypothesis may often be tested by experimental inquiry and the soundness of the original conception ascertained.

With this fact clearly brought to the student's notice the mathematical treatment is described in a concise manner, the accompanying diagrams greatly helping to this end.

This work certainly takes its place among the best elementary text-books on this subject.

AN EXPERIMENTAL COURSE OF PHYSICAL CHEMISTRY. By James F. Spencer. G. BELL & SONS, LTD., London, 1911. Vol. I. Pages 228+x, with Appendix and Index. Chaps. XIII, including 65 Illustrations. Price 3s. 6d. Vol. II. Pages 256+xvi, including Appendix and Index. Chaps. X, with 68 Illustrations. Price 3s. 6d.

It is claimed that this work is written to impart to the student an actual knowledge of the physico-chemical laws through the actual performance of experiments. The subject is certainly treated in a practical manner, and the nature of the numerous diagrams help to indicate the course the student should pursue. The chapter on the determination of density, for instance, at once defines the important consideration of the relative position of absolute density, specific gravity, and relative density before the student. The question of the estimation of the density of solids, and liquids, by different methods, is particularly well set out, also that of the density of gases and vapour density. The methods of determining molecular weight in solution, solubility determinations, vicosity and surface tension are equally well considered.

The second volume deals with determinations of a more difficult order, such as that of mass action, partition coefficients, conductivity of electrolytes, number and velocity of ions, electromotive forçe, and, finally, with thermo-chemistry, and radio-activity. It is evident from the careful manner in which the subject has been treated, that this work will be of considerable value to the student who wishes to obtain a real insight into his subject, and not merely to cram for an examination.

ELECTRO-ANALYSIS. By Edgar F. Smith. KEGAN PAUL, TRENCH, TRÜBNER & Co., LTD., London, 1912. 5th Revised Edition. Pages 332+viii, including Index. Divided into 2 parts and 8 sections, with 46 Illustrations. Price 10s. 6d. net.

This work has run into the fifth edition. The recent developments in electro-analysis are fully dealt with, and the advantage of this rapid method of analysis discussed in detail, special reference being made to the mercury cathode. The deposition of copper is naturally dealt with at length, a very complete reference to published work being included. The other metals, such as cadmium, bismuth, lead, silver, zinc, nickel, manganese, chromium, antimony, are then considered, and the actual separation of metals by this method discussed in detail. A final chapter deals with the combustion of organic compounds by electrical generation of heat.

Books Received.

"L'Histoire de la Chimie," by A. Colson. Pages 130, including Index and Conclusion. Chaps. 10. A. Hermann et Fils, Paris, 1910. Price 3 francs.

"Assaying and Metallurgical Analysis," by E. L. Rhead and A. Humboldt Sexton. 2nd Edition. Pages 451+x., including Appendix and Index. Divided into 3 parts and 38 sections, with numerous Illustrations. Longmans, Green, & Co., London, 1911. Price 12/6 net.

"Electro-Analysis," by Edgar F. Smith. 5th Revised Edition. Pages 332+viii., including Index. Divided into 2 parts and 8 sections, with 46 Illustrations. Kegan Paul, Trench, Trübner & Co., Ltd., London, 1912. Price 10/6 net.

"Qualitative Chemical Analysis of Inorganic Substances," by Olin Freeman Tower. 2nd Edition. Pages 84+xiii. Divided into 7 sections, including Appendix. P. Blakiston's Son & Co., Philadelphia, 1911. Price $1.00 net.

"Micropetrology for Beginners," by J. E. W. Rhodes. Pages 126+xii. 7 Chaps., including Appendices and Index. Numerous Illustrations. Longmans, Green, & Co., London, 1912. Price 2/6 net.

"A School Chemistry," by F. R. L. Wilson and G. W. Hedley. Pages 572+vii., including Index and Appendix. 32 Chaps., including 97 Illustrations. The Clarendon Press, Oxford, 1912. Price 4/6.

"An Experimental Course of Physical Chemistry," by James F. Spencer. Vol. I. Pages 228+x., with Appendix and Index. Chaps. 13, including 65 Illustrations. Price 3/6. Vol. II. Pages 256+xvi., including Appendix and Index. 10 Chaps., with 68 Illustrations. G. Bell & Sons, Ltd., London, 1911. Price 3/6.

"A Dictionary of Applied Chemistry," by Sir Edward Thorpe. Vol. I. Pages 758+viii. Numerous Illustrations. Longmans, Green, & Co., London, 1912. Price 45/- net.

CHEMICAL ENGINEERING.

NOTES ON THE SUGAR-BEET INDUSTRY.

By R. N. Dowling (Agricultural Adviser to The National Sugar-Beet Association, London).

In these short articles it is impossible to deal with the scientific and technical sides in detail, but it is the writer's hope that these observations, gathered in different countries in Europe, will afford an interesting impression of the different branches of the industry.

As one approaches a factory, a constant stream of carts and waggons is passed, some delivering beets and others returning loaded with pressed wet pulp for food for farm stock. The waggons are weighed over a weighbridge before and after unloading. It is the usual custom for sample quantities of a bushel to be taken from the waggons of each farmer for a few days at the beginning and at intervals during the season. These are weighed, washed and reweighed, in order to ascertain the amount of "tare" to be deducted. This usually amounts to from 10% to 20%.

German Beet-Sugar Factory.

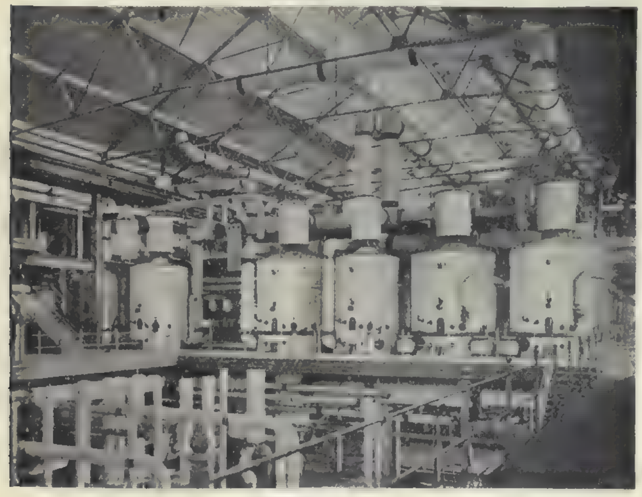
Sample roots are also analysed for their sugar content by means of the polariscope.

The factory yard presents a scene of great activity. Beets are being rapidly unloaded from the waggons and railway trucks into the open "flumes," and carried or "floated" into the factory by a stream of water forced along the bottom of these channels. Great heaps of beet are usually piled up, waiting to be taken into the factory.

In Holland it is usually the custom to deliver by means of barges on the canals or rivers. On the arrival of the water-conveyed beets in the building, they are elevated to a "washer" by a scoop wheel elevator, or by the more modern "mammoth pump," and, after passing through the washing trough, which is fitted with large revolving arms, they are taken to the top of the factory by means of a cup elevator, and tipped into an ingenious automatic weighing machine, thence by gravitation into the revolving slicing machines fitted with sharp knives, which slice the beets into regular pieces about three to four inches long by one-eighth inch in thickness. These slices are delivered to the diffusers by means of a travelling rake conveyor and shoots. The diffusion battery consists of a number of iron cylindrical cells or diffusers, which may hold as much as five tons of slices, and are fitted with movable cap tops and bases for filling and emptying. The hot juice and water is forced through the battery of cells, and the process of extracting the sugar by diffusion is set up.

The raw diffusion juice then passes from the diffusers into centripetal cylindrical strainers, after which it is measured automatically, heated in preboilers, and passed into the lime mixers to be mixed with quicklime which has been prepared by a kiln outside. The lime combines with the minerals, etc., and thus defecates or purifies the juice, as such stop crystallisation and are harmful in other ways, and thence passes to the carbonatation tanks. After the first "carbonatation" or "saturation" of the limed juice with Carbon dioxide (CO_2) (which is driven in to combine with and precipitate the lime), it passes through filter presses, which separate the calcium carbonate and the partly purified juice. This treatment is repeated in second carbonatation tanks and presses, and sometimes a third, where the alkalinity of the juice is finally adjusted. The purified thin juice passes on to the evaporators in order to evaporate some of the water and convert the thin juice from about 13° Brix. into a thick juice, having a density of about 60° Brix. To do this economically a set of four or five horizontal cylindrical bodies are used, and if four, we get the highly scientific quadruple effect. The first vessel is heated either by direct or exhaust steam or high pressure vapour from a juice pre-boiler. The vapour given off by the first cylinder heats the second, and that given off by the second heats the third, and that given off by the third heats the fourth. This is brought about by means of the condensation of the steam driven into the first vessel, the utilisation of the evaporation vapours, partial vacuums and varying atmospheric pressures, so that 1 lb. of steam will evaporate about four times as much as an ordinary open evaporator —*i.e.*, it has almost a fourfold economy. This thick juice is pumped to another carbonatation or sulphitating installation, and after treatment is again filtered and passes on to the vacuum pans, where it is boiled to "massecuite"—*i.e.*, a mixture of well-defined crystals and concentrated syrup. This massecuite is now discharged into crystallisers, where it is cooled down by stirring, thus allowing the "grain" to grow; and afterwards it is passed to the centrifugals, which, by the rapid revolving action, separates the crystals from the adhering syrup, the latter passing through the finely perforated periphery, leaving the crystals adhering to the sides of the centrifugal basket. This first sugar has a polarisation of about 96% to 97%.

The syrup is again treated by boiling, etc., as before, and after passing through a second lot of centrifugals, yields a sugar having a polarisation of about 90%. The resulting syrup forms the by-product called "molasses" or "agricultural treacle." The residual slices, which have been taken from the diffusers, are either pressed and delivered wet, or are conveyed to a "drying" plant, to obtain the well-known "dried slices" or "schnitzel." The cost of a factory dealing with 1,000 tons of sugar-beets in the 24 hours would probably be from £100,000 to £120,000, and *pro rata*, according to size.


Evaporation.

Such a factory would deal with about 80,000 tons of beets during the campaign. It would consume about 60 tons of coal and 40 tons of limestone in the 24 hours, and require something like 1,500 gallons of water per minute, unless a portion was purified after using, and thus used again, About 250 men would be employed during the "campaign," of say, 80 to 90 days, and 60 during the remainder of the year. On the Continent the other "hands" work in the fields or other industries, *e.g.*, brickmaking, during the summer months.

Costs and Returns.—The yield, of course, will vary according to circumstances, but, assuming normal conditions and proper treatment, a yield of 13 tons might be looked for on the average. Higher yields no doubt can be and are obtained—*e.g.*, Wye College last year obtained yields of from 15 to 21 tons of washed and topped roots per acre on experimental areas. The profit must vary according to the crop. Also it is probable that later an extra sum might be paid for every unit of sugar over a certain percentage. It is also not improbable that a bonus system might be inaugurated.

Root-Cutters and Diffusion Battery.

It is for the farmer to see that he gets a high yield with good sugar percentage.

Estimated Costs and Returns per Acre.

Sugar Beets.				Mangolds.				Swedes and Turnips.			
	£	s.	d.		£	s.	d.		£	s.	d.
13 tons washed, topped & delivered, at £1.	13	0	0	28 tons topped, tailed, cleaned and sliced, at 7*s.* 6*d.* ton ...	10	10	0	15 tons at 5s., if fed in yards, or say 250 sheep for one week at 30s. per 100 75*s*..	3	15	0
Leaves & tops .	0	15	0	Cost of producing crops, including topping, tailing and slicing ...	10	10	0	Manurial value after sheep, & value of treading land, say .	1	0	0
Value of portion of beet-pulp returned free, say 15*s*	0	15	0						4	15	0
Free seed, say, 20 lbs. at say	0	7	0					Cost, say £6 10*s*	6	10	0
Value of portion of lime returned free ...	0	3	0								
	15	0	0								
Total cost of producing crop and delivering to factory. (This could often be less) ...	12	0	0								
Net cash profit as soon as roots have been delivered, say in Oct. or Nov....	3	0	0	Profit	Nil.			Loss	1	15	0

These figures are given as a guide only and in an explanatory sense.

(*To be continued.*)

EFFICIENCY IN THE BOILER HOUSE.

By A. W. Bennis, M.I.Mech.E.

Self-Cleaning Compressed Air Furnaces Burning Slack.

The question of works' costs in the chemical manufacturing industry has not in many cases been properly considered. This item, which may so considerably affect the total of working expenses and works' costs generally, deals with the boiler-house, where the coal bill has its origin, and is either run up or kept down, according to the knowledge and skill of the engineer in charge. But the term "engineer" is sufficiently elastic to admit all sorts and conditions of men, and includes the genius that greatly dares when designing such works as the Panama Canal or the Tube Railways, and, on the other hand, the man who shovels coal on to the furnace fires in the boiler-house of an ordinary manufactory.

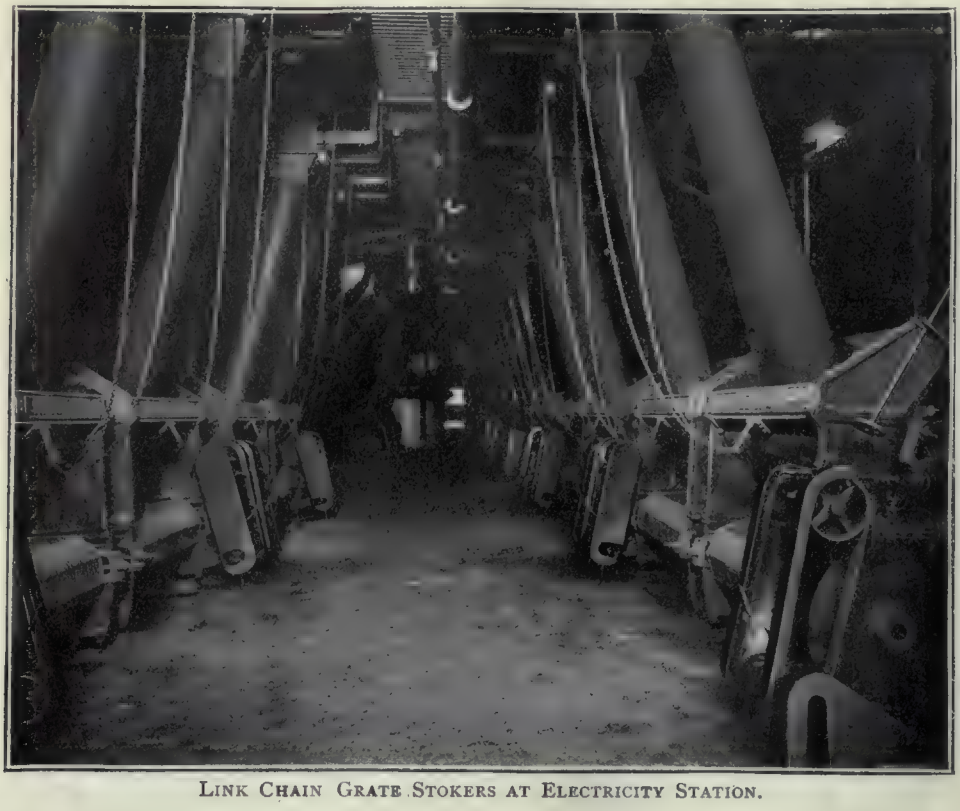
The coal merchant stands to the manufacturer in about the same relation that the printer stands to the author. Under ordinary conditions, if the costs of steam production are excessive, the coal is at fault, and it is the coal merchant who will hear of it. The chemical works offers no general exception to this haphazard estimation of the state of things, although it may be admitted that here and there a bright exception may be found which may influence others into action, but most of us soon become familiar with contrasts, and we cease to regard the phenomenon in its true value.

At the present time we can recall less than six leading chemical works where the production of "cheap steam," with a consequent reduction of the coal bill, is receiving the attention that it deserves. Wherever such attention is accorded either by the proprietors, or by an able man, supported by those in authority, the results amply justify it. At first surprise is awakened that low boiler duty, big coal bills and smoky chimneys, should be possible in the Chemical Industry, which is, as it were, the Capital of the world of science. How is it, one asks oneself, that chemists permit such a state of things to exist?

The more particularly does the pertinence of this question appear when it is realised that there are chemical manufactories where it is daily demonstrated that it pays, and pays well, to consider practically the problem of boiler-house economics.

Not a few of our big chemical works are situated in the North. It is in the North that cheap coal can be purchased, and it is with cheap coal that machine-firing can accomplish such desirable results. We append herewith a test which is well worth the careful study of engineers in charge of boiler-houses in chemical works.

The most careful and elaborate tests made by the manufacturers of stokers and the engineers representing the companies who use these stokers, have indisputably demonstrated that mechanical stoking is in every way more economical than hand-firing.



LINK CHAIN GRATE STOKERS AT ELECTRICITY STATION.

Report of boiler trial on a 30′0″ × 8′0″ Lancashire Boiler, fitted with the latest type "Bennis" Coking Stoker and Compressed Air Furnace at the works of Messrs. Peter Spence & Sons, Ltd., Alum Manufacturers, Manchester :—

Date of trial	1912	Jan. 11.
Duration of trial	hours	8
Heating surface of boiler	sq. ft.	998
Grate surface of boiler	sq. ft.	38
Average temperature of feed water,		
To economisers	°F.	52·6
To boiler	°F.	215·0
Average steam pressure	lbs. per sq. in.	89·9
Class of coal used		Bridgewater rough slack
Calorific value of coal	B. Th. U. per lb.	12,483
Total coal consumed	lbs.	10,542
Coal consumed per hour	lbs.	1,318
Coal consumed per sq. ft. grate surface per hour	lbs.	34.7
Total water evaporated	lbs.	85,874
Water evaporated per hour	lbs.	10,734
Water evaporated per hour as from and at 212°F.	lbs.	12,916
Water evaporated per sq. ft. heating surface per hour, as from and at 212°F. ...	lbs.	12·94
Water evaporated per lb. coal as from and at 212°F.	lbs.	9·802
Total thermal efficiency obtained	per cent.	75·83

The "Bennis" Stoker has increased the output of this boiler by 50% over the previous methods of firing, with an increased efficiency of 10% to 15%. The coal was carefully weighed, and the water was measured by means of tanks, which were carefully calibrated. During the whole period of the test the chimney was absolutely smokeless.

To crowd on as much coal at a time as the furnace will hold—the bigger the lumps the better—to shut the door and then trust to luck, has already been laid down by an imminent engineer, as "the main object in life of the average human stoker," and those who have practical acquaintance with the type will agree as to the accuracy of this description.

And here we would point out that the term "average fireman" implies that there is a fireman who may distinctly claim to be "beyond the average." Such a man recognises that the principle of good stoking is to fire lightly and often, and to keep the fires as regular and even as possible, and it is his constant aim to regulate the draught to the duty required, keep a clear fire, and an even steam line.

It is a recognised fact that in the actual manipulation of fires the efficiency of the individual fireman, even of the most expert, varies widely—the variation in results being as much as 22%.

F. Grover, in his "Notes on Boiler Testing," says on this point: *Stoking*—"In order to illustrate the personal element introduced into stoking, good and bad, we may quote the competition which was carried out by Messrs. Davy Bros., of Sheffield. Five stokers were made to fire the same boiler with the same coal, and with the steam pressure about the same. The best stoker was able to obtain an evaporation of 9 lbs. of water per pound of coal, the worst evaporation being 7·4 lbs. per pound of coal. The difference is here 22 per cent. The opportunities afforded for increasing the efficiency of the boilers were, in this instance, limited. A well-laid fire, which by constant attention is prevented from burning into holes, is one of the chief items in securing a high evaporation. Keeping the fire-bars clean, and regulating the damper for a maximum quantity of air, just after firing, contributes greatly to high efficiency. Beyond these points there is little opportunity for exercising skill in stoking, and yet these tests show clearly how very important the simple operations involved in firing a boiler become. The very simplicity is one cause of neglect."

In a Paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers, for the purpose of showing the relative cost of hand-firing in large plants, when compared with modern coal-handling equipment, combined with mechanical stokers, the following particulars were given, which were obtained from actual records in a large establishment, containing about 7,500 boiler horse-power. The plant was operated for some time after construction without coal-handling machinery of any kind except small hand-cars, which were loaded by hand from railway cars outside the building, and then hauled up a slight incline to the boilers. The cost is given for the month of May in one year, compared with May in the year following. In the first instance no mechanical means were employed. In the second, mechanical stokers and conveying machinery were used. The only handling necessary was that incurred by shovelling into the conveyor, and that might have been greatly cheapened by using a track hopper. Existing conditions made this impracticable. The cost of hand-firing compared with mechanical stoking is given as follows:—

Hand-Firing.—May: Sixteen firemen and one helper, wages, £196 7s. 2d.; tons burned, 4,292; cost per ton, 10·98d. Eleven coal and ash men wages, £126 18s. 8d.; cost per ton, 7·98d.

Machine Firing.—May: Three firemen and two helpers, wages £57 11s.; tons burned, 6,975; cost per ton, 1·98d. Eleven coal and ash men, £130 18s.; cost per ton, 4·50d.

It is the result of carefully conducted tests which bring out so clearly the disadvantage of the variation in hand-stoking, providing at the same time one of the strongest arguments in favour of the machine stoker which, when well-designed, fulfils the conditions of a good fireman and secures uniformity of product, the functions of the machine being varied, as required, by positive adjustment.

It would be late in the day to point out the advantages of machine-firing over hand-firing were Chemical Works at all on a par with the works of other industries in the matter of boiler-house equipment.

COMMERCIAL AND GENERAL NOTES.

Sulphate of Ammonia Enterprise in New Brunswick.

New Brunswick is to be the scene of action of an interesting commercial enterprise which has the object of developing the oil-shale lands of that colony for the distillation of oil and securing sulphate of ammonia and other by-products. A party of capitalists having acquired large tracts of suitable territory intend to spend about two million dollars in the construction of a plant with retort and refining machinery as used in the Scotch shale-oil fields. This new industry promises to be very profitable to the concern, besides providing employment to a considerable number of workmen.

An Opportunity for Exporters of Chemical Manure.

The demand for chemical manures in Austria promises to be extraordinary during the next few weeks, and British exporters should not miss this opportunity to secure a share of the trade. In order to encourage landowners and farmers to enrich their soil, after the impoverishment caused by the heat and drought of last summer, the Austrian Minister of Railways has decided to reduce the freight on chemical manure. The reduction represents 50% of the normal freight rates on all Government railways within the empire. The following articles will benefit by this decision: nitrate of soda, kainite, potash salts, bone-meal and superphosphate.

Nitrogen as a By-Product of Aluminium Manufacture.

An interesting French concern has recently been formed for the purpose of producing nitrogenous products as by-products of aluminium manufacture. The "Société l'Aluminium Français" intends to work according to the methods in use at the "Société Générale de Nitrures." This company was founded in 1906 as a branch establishment of the aluminium factory of the "Compagnie des Produits Chimiques d'Alais." Its purpose was the working of a new invention for the production of ammonia fertilizers by fixing nitrogen on crude aluminium. The new concern seems to offer very favourable prospects, as the working of the process in question is said to be very profitable, and its progress will be watched with interest by all connected with the industry.

Radium Deposits underneath the City of Budapest.

A novel theory on the origin of the heat of the famous hot springs of Ofen has been propounded by Dr. Julius Weszelszky. In a lecture on the results of his radiological studies, he remarked that he devoted particular attention to an examination of the hot springs in the vicinity of Budapest. These studies led him to believe that the cause of the remarkable heat of the hot springs at Ofen is to be found in a huge deposit of radium underneath the town of Budapest. This alone seems to explain the heat, which varies from 40—70°C. Austrian and German scientists express considerable doubt as to the probability of such a deposit and look forward with interest to actual proofs of its presence.

A Gold Medal for Leadless Paint.

In connection with the campaign against lead-poisoning on the Continent, the interesting announcement is made that the Committee of the Industrial Association for Lower Austria has decided to offer its gold medal for the best method of preparing leadless printing and lithographic colours, representing a perfect substitute for colours containing lead which are at present in use, such as lead-white, chrome yellow, etc. The substitute must give the same results as regards spreading power and appearance without endangering the printer's health. The Industrial Association also offers its gold medal for the best bronze paints ready for printing, giving the same results as bronze powder. Competitors should address their application to the Secretary of the Industrial Association (Eschenbachgasse, 11—Vienna 1) before April 30th, 1912.

The Argentine Republic as a Market for Chemicals and Paints.

This progressive of South American States offers an important field to the exporter of chemicals and paints. The growing importance of the market is illustrated not only by the great number of new products which are constantly required but also by the increasing quantities imported. The demand is likely to improve still further, since the industrial development of the country makes remarkable progress. Among the articles which are sold in considerable quantities are sulphate of copper, soda and numerous chemicals for medical purposes. These are partly obtained from France and England and partly from Germany and the United States. Another important class of goods suitable for the Argentine markets are colours and varnishes of all kinds. The quantities and values of the imports of these in 1909 and 1910 are shown in the following table :—

	1909. QUANTITY.	1909. VALUE.	1910. QUANTITY.	1910. VALUE.
Aniline Dyes … …	178,836 Kg.	156,021 Pes.	204.954 Kg.	178,509 Pes.
Varnishes … … ..	553,128 ,,	401,063 ,,	577,946 ,,	442,812 ,,
Powdered Pigm.… …	3,680,667 ,,	266,342 ,,	3,663,722 ,,	281,219 ,,
Mixed Paints … …	4,438,023 ,,	520,274 ,,	4,896,383 ,,	602,870 ,,
Enamels .. … ..	521,527 ,,	236,787 ,,	684,372 ,,	307,650 ,,

Aniline dyes are a speciality of the Germans, who exported 164,862 Kg. of the total quantity (204,954 Kg.) imported in 1910, but varnishes are largely bought from the United Kingdom (324,793 Kg.), while the United States sent 97,518 Kg. Germany's share of the varnish trade amounted only to 39,311 Kg. and Holland's to 32,911 Kg. It is a matter of congratulation that Great Britain has also the lion's share of the trade with ready-mixed paints. In 1910 the imports of British mixed paints amounted to 3,668,457 Kg., which compares with only 470,820 Kg. of German origin. As regards enamels the United States are formidable competitors of the British exporters, and in 1910 the imports of American enamels (270,683 Kg.) were considerably larger than those of the British products (79,436 Kg.) There is every reason why British exporters should secure a still larger share in the trade with the South American Republic as an enormous amount of British capital has been invested in its industries and our products have obtained a high reputation. It seems, therefore, to be merely a matter of pushing trade more energetically, and studying the requirements of the market as carefully as our German and American rivals are in the habit of doing.

A Paint Destroying Fungus.

In a recent issue of the *Kew Bulletin,* Mr. Massee describes a remarkable organism which specialises in the destruction of paint. This fungus flourishes in hot houses where it may do great damage. Experiments made by Mr. Massee show that when this paint-destroying fungus—which he appropriately names *phonia pigmentivora*—is cultivated in linseed oil, it remains uncoloured, but when the spores are sown on a streak of wet paint they germinate and produce rosy blotches, which in the course of a few weeks become deep purple. The striking colour appears to be due to the production of an oxide of lead from the white lead—carbonate—used in the paint. By the addition of 2 per cent. of carbolic acid to the paint, the spores are prevented from germinating and the work of painting is not rendered useless by this pest.

The Ibean Camphor Tree of the East African Protectorate.

In a recently published Colonial Report, attention was drawn to a tree which seemed of considerable economic importance, as it promised to furnish a substance similar to camphor. The subject was of sufficient interest to justify further investigation, and in response to a request from the Imperial Institute, specimens of the wood were obtained from East Africa. The results of the investigations show that the younger parts of the "Ibean Camphor" tree, such as twigs, leaves, branches and sapwood, yield small quantities of volatile oil containing cineol, the characteristic constituent of eucalyptus oil. The quantity of oil obtained is too small to make the wood of value as a source of volatile oil, and in any case the latter would only be a poor substitute for eucalyptus oil. Its presence in the wood, however, no doubt exerts a certain antiseptic and preservative action, so that it should have the property of lasting well and should be less susceptible to decay than woods free from volatile oils of this type.

It is a little unfortunate that the name "Ibean Camphor" has been adopted for this tree, since it at first gave rise to the impression that a new source of camphor had been discovered in East Africa. With a view of correcting this impression the above facts have been stated.

American Honours for a German Scientist.

The annual presentation of the Perkins gold medal took place at the recent meeting of the New York Section of the Society of Chemical Industry. It was conferred on Mr. Herman Frasch "in recognition of his valuable work in applied chemistry."

Some of the inventions which have secured Mr. Frasch a prominent position in the ranks of modern chemists are connected with the oil industry, such as a process for removing from the heavier burning fraction of the oil the sulphuric acid taken up during the acid treatment by the cracked products. In 1890, Mr. Frasch applied for a patent for an improvement in the sulphur industry. It had long been known that there was a large deposit of sulphur in a certain section of Louisiana at a depth of 1,000 feet below the surface, but attempts to bring the sulphur to the surface had failed on account of the layers of quicksand above the deposit. Mr. Frasch evolved the idea of melting the sulphur *in situ* by means of superheated water at more than 300°F. forced down a boring and forcing the melted sulphur to the surface through an inner tube.

M. L.

"THE ACTION OF THE RESPIRATORY ENZYMES OF SAUROMATUM VENOSUM SCHOTT."

BY DR. TH. WEEVERS.

(*Continued from Page 70.*)

Decomposition of glucose has taken place in all my experiments, in those in the air, as well as in those in a hydrogen atmosphere, carbonic acid and organic acids are always formed, but no alcohol, an enzyme identical with zymase cannot therefore have acted in this case, the more so because in the experiments of Kostytschew and Palladin[12] the production of organic acid never occurred at all.

In the anærobiosis of *Agaricinae* Kostytschew[13] also found production of CO_2 without formation of alcohol; Palladin and Kostytschew[14] pointed out that in the absence of carbohydrates carbonic acid is similarly formed by old etiolated shoots of *Vicia Faba*, but without alcohol.

Indeed, in all these experiments, which were for the most part conducted with intact parts, killed by freezing, formation of acids never took place, at least it is never mentioned. Only in the much discussed experiments of Stoklasa[15] is there any question of the production of acid. In these the press juices of sugar-beet, barley, peas and lupin seedlings were treated with alcohol and the precipitate was used for the experiments. On addition of glucose the latter was decomposed and there resulted CO_2 organic acids, and alcohol. The organic acids were chiefly lactic, acetic and formic, whereas it will be shown that these acids were absent in my own experiments.

The above described action of the respiratory enzymes of *Sauromatum* seems therefore to be very specific and shows much agreement with the action of the press juice of *Arum maculatum* only; the considerable formation of acid reminds us of the metabolic processes of Fungi in which so often acids are formed and of the nocturnal production of acids in *Crassulaceæ*, in which according to more recent investigations the formation of acid may be connected with the decomposition of carbohydrates.[16] The question now is, what acids are formed in the decomposition of glucose by the enzyme of *Sauromatum venosum*?

The quantity of liquid which was not required for the other experiments was evaporated, extracted with ether and the ethereal extract used for further investigations. The small quantity available was not sufficient for macrochemical investigation, I therefore made the analysis in about the same way as that described by H. Behrens.[17]

The ether was distilled off and water added. First of all I tried, whether the acid was volatile with steam; this turned out not to be the case, only a minute quantity passed over, too small for further investigation. Moreover the liquid had already boiled for a few minutes as described above, and the odour then indicated traces of butyric acid.

The acid reaction is therefore not caused by formic, acetic or propionic acid, nor by higher fatty acids.

By sublimation on a microscopic slide a sublimate was only obtained at a fairly high temperature, when the substance was coloured brown. The sublimate was not crystalline even when breathed on, so that it cannot be oxalic or succinic acid. The test with lead acetate for malonic acid yielded an equally negative result.

On the other hand the aqueous solution gave distinctly Berg's test,[18] *i.e.*, a yellow colouration with a solution of two drops $FeCl_3$ 45°B and two drops HCl 22°B in 100 cc. water. This reaction is peculiar to organic acids with one or more CHOH groups, oxyacids, therefore, of which the best known are lactic, tartaric, malic and citric acid.

The test for cobaltolead lactate as well as for potassium and silver bitartrate gave a negative result, the two first mentioned acids are absent. Testing with $AgNO_3$, the presence of citric acid, was shown by the crystals of silver citrate (see Behrens). Citraconic acid must therefore be present in the sublimate and after adding NH_3, evaporating and redissolving in water, crystals of the thallous salt of citraconic acid were actually obtained on adding thallous nitrate.

Once I obtained crystals of silver malate, after the addition of $Ag\,NO_3$; it might therefore be possible that malic acid was here formed as well as citric acid.

Both acids are known to be final or intermediate products in the decomposition of sugar. I have already mentioned malic acid[19] in this connection and Wehmer[20] has shown that *Citromyces spec*, *Penicillium luteum* and *Mucor pyriformis*, when grown in sugar solutions, produce citric acid; this acid also frequently occurs in Phanerogams (*comp.* Czapek, *Biochemie der Pflanzen*).

Whether in addition to citric and perhaps malic acid, other less known acids are also formed by the enzyme in the decomposition of glucose is, of course, still an open question.

If we calculate the quantities of acid found as citric acid [$C_3H_4OH\ (COOH)_3 + H_2O$, mol. weight 210] we find:

I.	experim.	for	77	mg. glucose	34	mg. CO_2 and	63	mg. citric acid.
II.	,,	,,	240	,,	140	,,	175	,, ,,
V.	,,	,,	35	,,	27	,,	15·5	,, ,,
VI.	,,	,,	32	,,	14	,,	17·5	,, ,,

It is my intention by using more material to determine the quantity of citric acid formed, for only then can it be ascertained whether the decomposition of sugar to CO_2 and citric acid is complete. It seems natural at the same time to investigate what enzymes are present in the crude enzyme, whether oxygen is absorbed in the process and how the object behaves after freezing by Palladin's method, questions which the method explained above leaves unanswered.

The results of this investigation can be summarised as follows:—

By pressing out and precipitating the press juice with alcohol or acetone, there can be obtained from the spadix of *Sauromatum venosum Schott.* a crude enzyme, that decomposes glucose with the formation of carbonic and organic acids, but without any production of alcohol neither in the air nor in a hydrogen atmosphere.

Destruction of the cellular structure and treatment with alcohol or acetone do not therefore inactivate the respiratory enzymes in the present case, their power of decomposing sugar remains very marked.

In the same way a crude enzyme is obtained from the leaves of *Sauromatum*, which is similar, but has a weaker action.

In the ether extract of the acid liquid citric acid was demonstrated, which acid very probably must be formed by the respiratory enzymes at the expense of the glucose.

Amersfoort, September, 1911.

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[12] Palladin and Kostytschew, *Ber. d. d. bot. Ges.*, 1906.

[13] Kostytschew, *Ber. d. d. bot. Ges.*, 1907.

[14] Palladin and Kostytschew, *Ber. d. d. bot. Ges.*, 1907.

[15] J. Stoklasa, Adolf Erne t. Karl Chocensky, *Ber. d. d. bot. Ges.*, 1907.

[16] Hugo de Vries, *Verh. Konink. Akad.* v. Wet, 1884.
G. Kraus, *Abhandl. naturf. Ges., Halle*, 1884.
O. Warburg, *Unters. bot. Inst., Tubingen*, 1886.
A. Mayer, *Landw. Versuchsst*, 1887.
K. Puriewitsch, *Bot. Centr.*, 1894.

[17] H. Behrens, *Anl. zur mikrochem, Analyse 4e Heft*, 1897.

[18] Berg et Gerber, *Bull. soc. chim.* 1896.

[19] A preliminary experiment was carried out in order to obtain from the leaves of *Echeveria spec.* in the same way as here from *Sauromatum*.

The malic acid of *Crassulaceæ* has been investigated by J. H. Aberson (*Ber. Chem. Ges.*, 1898).

[20] C. Wehmer, *Ber. d. d. bot. Ges.*, 1893.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

23573/10. W. P. COHOE, Toronto. *Glucose-like Product.* 11 October, 1910.

For obtaining a glucose-like product from cellulosic material and ligneous material, a charge of sawdust or like material with its normal content of moisture is placed in a digester and subjected therein to the action of steam under pressure, until such time as the volatile organic compounds resulting from the action of the steam on the wood are in large proportion driven off. The organic compounds consist mainly of acetic acid. The acetic acid vapours are withdrawn from the digester, and the mass of sawdust is then further digested under pressure, and at a high temperature in the presence of a vaporous hydrolizing acid. (6 claims, 1 Fig.)

100/11. L. E. BUSSEY, London. *Copper Treatment.* 2 January, 1911.

Copper is extracted from ore containing that metal by leaching the ore with sulphurous acid and passing air through the solution, so as to remove the excess of sulphurous acid and render the solution suitable for electrodeposition. (2 claims.)

3263/11. E. DAPINO, London. *Sewage Treatment.* 8 February, 1911.

The invention relates to tanks or pits used in the bacterial or septic treatment of sewage, and to that type of tank or pit which is built underground, and consists of a series of chambers successively communicating with one another, into the first of which the sewage is delivered. The sewage escapes from the last chamber in the desired state, after flowing through the intermediate chambers, one of which is adapted to constitute a filter. The invention deals in particular with the filtering chamber, which is divided into a number of compartments or spaces, so arranged that the sewage is compelled to follow a sinuous course. (3 claims, 5 Figs.)

8161/11. W. HERDT, Wilmersdorf, and A. FRAASS, Berlin. *Artificial Stone.* Dated under International Convention, as 6 April, 1910.

According to the present invention, a homogeneous artificial stone is prepared by mixing asbestos and talc in a solution of chloride of magnesuim and adding the necessary quantity of burnt magnesite when required for use, filling and colouring materials, if desired, being incorporated in the mixture, before or with the burnt magnesite. (2 claims.)

9461/11. A. TARAUD and P. TRUCHOT, Paris. *Sulphuric Acid.* Dated under International Convention, as 18 April, 1910.

To recover the nitrous products which are carried over by the residuary gases, leaving the Guy-Lussac towers of a lead chamber sulphuric acid plant, the gases are first submitted to treatment with alkaline earth carbonates, in order to retain any sulphuric acid that may be carried by the gases, and secondly to treatment with alkaline caustic or carbonated solutions for the absorption of the nitrous products. (2 claims.)

10216/11. THE FIRM W. HIESTRICH, NACHF., Hamburg. *Indiarubber Extraction.* Dated under International Convention, as 23 July, 1910.

The invention relates to a process and apparatus for the extraction of indiarubber, and, according thereto, the crude rubber, without preliminary washing, is placed in an extracting vessel along with a solvent. In the extracting vessel there is a plurality of parallel horizontal shafts with juxtaposed knives arranged to work together as in scissors. The shafts are revolved and the knives cut up the material. This action is effected at a temperature insufficient to decompose the material. After the material has been cut up, the solvent acts thereon to remove the resinous matters and impurities. The knives on the shafts are so disposed that they can only cut up the material periodically and in groups. (4 claims, 3 Figs.)

12555/11. K. SCHICK and ACTIEN-GESELLSCHAFT FÜR STICKSTOFFDÜNGER Knapsack, Germany. *Nitrogen Compounds.* Dated under International Convention, as 9 November, 1910.

A process for the production of nitrogen compounds from carbides and nitrogen consists, according to this invention, in adding predetermined quantities of halogen salts gradually to molten carbide as it flows out of a carbide furnace; the mixture is then allowed to set, and is treated whilst still in the red-hot condition with nitrogen. (1 claim.)

15656/11. G. E. HEYL, London. *Artificial Paving.* 5 July, 1911.

Paving slabs are made from fibrous paper material impregnated, and coated with indiarubber solution, oil, tar or pitch. The fibrous paper material is wound on a collapsible mandrel until the desired cross section is obtained, the mandrel then being withdrawn, the hole plugged with suitable material, and the block sliced or cut transversely into slabs. (3 claims.)

17626/11. M. PETZOLD, Zittau. *Soda-lye Purification.* Dated under International Convention, as 2 December, 1910.

Soda-lye rendered impure by the mercerisation process is purified, according to this invention, by treating the waste lye containing size with a mixture of lime and clay; an agent for effecting flocculence may be added to the mixture of lye, lime and clay. (2 claims.)

17704/11. E. SCHEITLIN, Basel-Stadt. *Metallic Sodium.* Dated under International Convention, as 20 August, 1910.

In a furnace for the production of metallic sodium by the electrolytic process and in a furnace in which the walls are used as anode, the receptacle receiving the melt is made circular so that two anode faces are formed located one within the other. The cathode is disposed between the concentric anode faces, and is constituted by U-shaped arms. (3 claims, 2 Figs.)

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A PROFESSIONAL QUESTION.

A MATTER has recently come to the front, which will demand the careful attention of the public analyst in this country.

From the point of view of the individual chemist, it may be held that he has the right to dispose of his own time, knowledge and skill as he pleases; but from the point of view of the profession as a body, it is clear that the maintenance of status is an important matter, and that such maintenance is dependent on two essentials: community of interests and mutual responsibility. Otherwise, progress would be retrograde, and the actions of irresponsible individuals tend to damage the whole body. It is, therefore, expected that no individual member will be a party to any proceeding which is likely to injure his professional brethren; indeed, every member should be ready, on occasions, to make his own personal interests subservient to those of the profession generally. The recognition of these principles is the basis of that solidarity which is necessary for the commonweal of every profession.

Efficient service can only be attained by the employment of the competent, and in return for such service, the chemist has a right to expect due recognition of his status, such recognition embracing adequate remuneration. There is nothing derogatory in this contention: the time has long passed since it was held—as Aristotle held—that the standard of thought was lowered by attempting to turn scientific knowledge to practical ends, and that science should be pursued without thought of material gain. Chemists are not trained to be philanthropists, but to take their part in every-day life as useful citizens.

The Council of the Institute of Chemistry have raised a protest against the attitude of certain local authorities in respect of the conditions proposed for the appointments of their public analysts. The Councils of the Metropolitan Boroughs of Lambeth and Wandsworth recently sought, in each case, the services of a competent person, who should be required to provide and maintain a laboratory, with all necessary equipment and assistance for adequately and completely carrying out the duties of a public analyst, and to examine and report on 2,000 samples, in return for an annual remuneration of £500. Our contemporary, *The Lancet*, has truly stated that, "The living wage is left entirely out of the proposition, and such a policy must sooner or later bring discredit upon a very important department of public service."

In another case, that of the County of Antrim, it is sought to appoint an analyst to examine at least 800 samples per annum for a remuneration of £150, the analyst providing laboratory, etc.

The Council of the Institute, in directing the attention of Fellows and Associates to the terms of the proposed appointments, expressed the opinion that the remuneration and conditions were not compatible with the adequate and complete execution of the duties involved, and that it was contrary to the public interest that the appointments should be made on such terms. The Council stated further, that they viewed with the strongest disapproval the application for and acceptance of the appointments on those terms; they advised that any member who had already made application for any of them should withdraw the same; and that members should refrain from giving testimonials in support of any candidate applying for them.

If the action of the Council has been somewhat drastic, it was none the less fully justified, and it is interesting to record that it was warmly endorsed at the recent annual general meeting of the Institute. It is certain that the selection of candidates for appointments of public analysts will be undesirably limited, and the administration of the Acts will suffer, unless an endeavour is made to obtain adequate recognition of the services of these indispensable officers.

The subject is one which requires the serious attention of the chemist. It is as important to members of this profession as it is to the medical, or legal one. It is only by a general and concerted movement that the position can be brought clearly before the general public, so that they can realise that in the present days of keen competition, the chemist alone stands between the public and the professional adulterator.

Borough Councils.

It is perhaps too much to expect that Borough Councillors should know that a public analyst must have undergone an education analogous to that of a medical man or a lawyer, and that the qualification of Fellowship of the Institute of Chemistry is not obtainable without at least six years' special training and experience, in addition to severe examinational tests, conducted on lines prescribed by the Local Government Board. Nor is it likely that more than a few members of any Borough Council have any knowledge of the administration of the Sale of Food and Drugs Acts. The Local Government Board, in their endeavour to combat the subtleties of sophistication as now practised, spare no pains to circumvent the law-breakers, but the constant issue of new regulations greatly increases the work of the public analysts and adds to their responsibilities, in return for which any diminution in the emoluments is, to say the least, unfair.

It is to be hoped that local authorities generally will pay more regard to the views of the Institute than the Borough Councils mentioned have done; and that the protest now made will bring home to the Local Government Board the urgent necessity of taking definite steps to protect the interests of public officers appointed under Acts which the Board controls.

Art, Science, and Industry.

The recent address of the President of the Silk Association calls for special comment. The figures given indicate an extraordinary condition for an industry which has been regarded in the past as an English one. It is only necessary to draw attention to the following table illustrating the decrease in the number of persons employed in this industry decennially since 1851. It is thought that the results for 1911 will show a further movement in the same direction :—

The Number of Persons Employed in the Silk Industry in the United Kingdom decennially from 1851 to 1901.

Year.	Males.	Females.	Total.
1851 ...	53,936	76,787	130,723
1861 ...	43,732	72,588	116,320
1871 ...	29,225	53,738	82,963
1881 ...	22,205	42,630	64,835
1891 ...	19,090	32,937	52,027
1901 ...	11,058	26,422	37,480

That this decrease is not connected with any increased efficiency in labour due to mechanical devices is shown by the corresponding figures for the imports of the raw material for the corresponding years, although the silk waste imported is evidently increasing :—

Imports of Raw, Thrown and Waste Silk, decennially from 1851 to 1911.

Year.	Raw.	Thrown and Spun.	Waste.
	lbs.	lbs.	cwts.
1851 ...	4,608,336	412,636	14,073
1861 ...	8,710,681	124.574	29.627
1871 ...	8,253,335	177,386	38,984
1881 ...	2,904,580	131,836	54,119
1891 ...	2,434,609	581,867	77,556
1901 ...	1,332,480	624,859	48,162
1911 ...	1,[illegible]38,775	736,630	81,261

The point to consider is that the imports of manufactured silk goods has enormously increased, as the following figures will show :—

Imports of Silk Manufacturers, decennially from 1851 to 1911.

Year.	Values.
	£
1851	Not obtainable.
1861	5,906,029
1871	8,397,938
1881	11.727,397
1891	11,179,588
1901	13,030.321
1911	12,765,497

So that if there had been any equivalent movement in this country, the employment table should have correspondingly increased.

The facts connected with this state of decay seem to be due to the material divorce of science and industry, and the fact that the essential conditions of manufacture claim a specially close partnership between art (as expressed in design), science, and industrial enterprise.

This is a combination which must be an uncommon one in this country under anything like present conditions, but it is one which must exist before any real advance is made in this industry, which gives work, under satisfactory conditions, to so many on the Continent and America.

A certain factor which has been emphasised is, that the raw material is not produced in this country, but this condition equally well applies to the jute industry. Many other reasons may possibly be contributing ones, but the essential factor is this combination, which is to a great extent absent here.

Mr. Frank Warner well stated the case when he said that " any improvement in this industry must be gained by sheer pluck and hard fighting over ground thickly set with obstacles."

INDUSTRIAL LEAD POISONING.

By C. A. Klein.

Lead Poisoning (as a disease of occupation) is of considerable technical importance, and in many countries this has been recognised by the application of State Regulations enforcing protective measures to the various industries in which lead poisoning has manifested itself to any considerable extent. In view of the public interest recently shown in the subject, it is desirable to compare the present position in this country with that of some few years ago.

The following figures are taken from the published official figures of the Home Office, and refer to English industries :—

Industry.	Average 1904 – 1906.		1910.		1911.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Smelting of Metals ..			54	5	48	3
Brass Works			7	—	9	1
Sheet Lead & Lead Piping			4	—	12	—
Plumbing and Soldering			25	1	37	[illegible]
Printing			33	4	32	2
File Cutting			9	1	18	2
Tinning of Metals ...			17	—	13	—
Litho Transfer Works ..			1	—	1	—
Glass Cutting & Polishing			—	—	5	—
Other Industries	403·3	20·3	47	3	88	4
Ship Building . ..			21	2	36	6
Paint used in other Industries			51	3	56	1
Coach and Car Painting...			70	6	104	5
Paint and Colour Works			17	1	21	—
Electric Accumulator Works			31	—	24	1
Vitreous Enamelling ...			17	—	19	1
Red Lead Works ...			10	—	13	1
White Lead Works ...	104·6	3·3	34	1	41	[illegible]
China and Earthenware ...	99·0	3·6	78	11	92	6
House Painters & Plumbers	190·3	34·3	232	35	263	48
Total ...	797·2	61·5	738	73	9 2	85

The total figures for 1911 show an enormous increase on previous years, yet the most prominent feature of the tabulation is the reduction of cases reported from white lead works. This is the more interesting when it is realised that it is the use of the products of such works which contributes the major portion of the other reported cases, as is evident from a consideration of official returns, and further, that the danger of white lead manufacture is much more intense than that in other industries dealing with lead.

A study of the steps by which the reduction has been accomplished cannot fail to be of value when the significance of the decrease is appreciated.

It must be stated that the output of the English white lead works has increased during the period under consideration, and, further, the Workmen's Compensation Act, which renders employers liable for compensation, has taken effect during this period. Both are causes likely to increase the number of reported cases, so that the marked decrease emphasises the efficiency of the protective measures adopted.

The Home Office rules for white lead works have been in operation for some years, and these have done much towards the establishing of hygienic conditions. Manufacturers have entered into the spirit of the regulations, and in many cases have supplemented these in their own works on lines indicated by experience.

Briefly, the protective measures adopted are as follows :—

1. Education of workers to a true appreciation of the dangers to which they are subjected.
2. Provision of overalls, adequate washing appliances, and baths, respirators, medical supervision, and nourishment.
3. Exercise of care in selection of workers having due regard to the problem of natural predisposition, general habits and alcoholism.
4. Elaborate precautions for the prevention of dust, with minimum personal handling of dry lead products.

The foregoing have been carried into effect as follows :—

Education of Worker.—By means of pamphlet stating in clear and simple language the poisonous nature of all lead products, how these may enter the system, what primary effects appear, and what precautions should be taken. The pamphlet is not an elaborate medical treatise, but is worded in plain, blunt English.

Overalls, Washing, etc.—Each worker is required to wash before meals (in the employer's time) and must bath weekly. Overalls are provided and are washed weekly. Respirators also for dusty work, and these are cleansed at least once each shift, or more often if necessary. Medical inspection takes place weekly, but here much depends on the worker, as there is a marked tendency to be secretive in their replies to the queries of the doctor, fearing that preliminary symptoms might prejudice their further employment. Nourishment in the form of cocoa or milk is provided for each worker before starting work and at meal times. Experience has shown that milk is of the greatest possible value, and this has almost entirely displaced the old-fashioned sulphuric acid drink, which was of questionable value.

Simple medicines such as Epsom salts, castor oil and sulphur tablets are provided, and in one English works sodium sulphide pills have proved to be very efficient, due to the comparative insolubility of lead sulphide in gastric juices. Incidentally, it may be mentioned that Dr. Goadby has observed that Italians who are engaged in white lead works seldom contract lead poisoning. It is noteworthy that these workers do not drink much beer, eat a lot of rough food and vegetables, and a large quantity of garlic (the sulphur of which appears to have beneficial results).

Selection of Workers.—This can only be a gradual process. A worker can never be judged by his face value as a lead worker. Medical inspection weeds out the obviously unhealthy and undesirable employees, but gives no positive indication of suitability. It is only by careful observation of the man at work that "dirty" workers can be discovered. This observation is made by a reliable worker of foreman status, who acts as inspector, and instructs the new worker as to the methods of avoiding the creation of dust in his work. The employment of casual labour is dangerous, and should be avoided. Dr. T. M. Legge, in the special report of 1898, *re* white lead works, gives the incidence of lead poisoning amongst casual labour as 39%, against 6% for regular employment.

The home conditions of a man are often a safe guide to his suitability for employment. Good home conditions mean good nourishment and habits.

The efficiency of regulations has been clearly demonstrated by the results obtained both in England and on the Continent, and it is quite certain that lead poisoning is amenable to regulations when the sources of trouble can be defined.

The following Continental statistics support this conclusion very clearly.

Dr. Ignaz Kaup shows the results obtained by the introduction of Prussian State Regulations concerning painters in 1905:—

	Cases.	Days Sickness.
1904 before regulations ...	391	12,246
1908 after 3 years' regulations	259	6,211

i.e., a decrease of 34·55% in number of cases, 50·71% in days of sickness, and 23·46% in average days per case, thereby indicating a considerable reduction in the severity of attack.

Dr. Josef Rambousek gives the following figures as representing the results of remedial measures effected by him in a lead colour factory near Prague:—

	1906	1907	1908	1909	1910
Cases	25	16	7	2	2 (doubtful).

The application of regulations of a standard type to all trades is not possible owing to the different conditions of employment, and it is therefore necessary to consider in some detail the two occupations which have shown the greatest increase in the period under consideration.

Coach and Car Painting.—The dangers of these processes appear to accrue mainly from the dust arising in various ways, and by the direct handling of the painting materials. This work is usually carried out inside a workshop, and therefore the application of regulations enforcing washing appliances, overalls, prohibition of dry rubbing down and the handling of dry paint materials, provision of exhaust draught, would not be of great difficulty, and would certainly have a salutary effect.

House Painters and Plumbers.—The figures reported are incomplete, as notification is not compulsory under the Factory and Workshop Act. The exact number of cases is unknown, and this is much to be regretted, because it allows of speculation, which is most undesirable in the consideration of questions of industrial illness.

Painters in England are not subject to any Government Regulations, except when engaged inside factories, although Belgium, Germany, Switzerland and Austria have regulations in force, and it is expected that Holland will shortly follow their example, as a result of an enquiry extending from 1903-1909. France holds a somewhat novel position in this connection. A law of 20th July, 1909, prohibits the use of white lead by house painters after 1st January, 1915, though this prohibition does not apply to coach painting; moreover, indefinite latitude is allowed a Minister in the application of the law. If prohibition takes effect, it would constitute an unfortunate record of inability to deal fairly with a question of industrial hygiene. Prohibition is a protective measure of fundamental simplicity and of unquestionable efficiency, yet its application to all dangerous trades would be the most effective barrier to progress ever devised.

A Departmental Committee of the English Home Office is at present engaged in an enquiry as to the use of lead products in house, car and coach painting. It is generally hoped that the enquiry will result in the framing of regulations which will effect a real reduction in the lead sickness now prevalent amongst workers in these trades. There would appear to be no reason why such regulations should be irksome to either employer or employed.

The chief sources of danger to which the painter is exposed can be stated as follows:—

1. Lead products taken to the mouth through the partaking of food with unclean hands.
2. The inhalation of lead-dust laden air created by dry rubbing or mixing of dry colour.

The risk of danger could be minimised by regulations framed to combat the above causes. The enforcing of such regulations is rendered somewhat difficult by reason of the scattered nature of the work where one or two men are despatched to carry out work, and much depends on the worker observing the necessary rules.

In order to obtain the maximum efficiency from any regulations, it is necessary to enlist the sympathy of the worker, and this can only be done by clearly pointing out to him the sources of danger.

The painter is adversely affected by seasons, for in summer long hours are worked under considerable pressure, this often following on a period of slackness of work, when nourishment has been necessarily reduced, and, as a result, resistance is impaired.

The first noticeable effect of lead absorption is the appearance of lethargy, a distaste for food, accompanied by fœtid breath, with a sweet taste in the mouth. The blue line on the gum is not now accepted as being more than an indication of contact with lead products. It is by no means general, and is not observed in workers who are in the habit of cleansing their teeth or whose teeth are sound.

Constipation and anæmia frequently appear at an early stage, often accompanied by a pronounced cachetic facial expression, tremor and cholic of a distinct character follow, whilst the later stages vary considerably. Falling out of hair, loosening of teeth, appearance of lead in urine, and kidney trouble are amongst the symptoms noted.

Wrist drop and paralysis indicate an advanced stage, and are by no means as common as formerly, owing to increased medical vigilance in the earlier stages.

It is impossible to outline any regular sequence of symptoms, for it is sometimes found that the poisoning rapidly assumes the most serious phase —*e.g.*, affection of the brain—with little or no warning.

The symptoms are in no way wholly characteristic, and frequently present some difficulty in diagnosis without the previous history is known. This has unquestionably produced an upward tendency in the number of reported cases, many of which are of doubtful lead origin.

In conclusion, lead poisoning is a serious problem of industrial hygiene. Public attention has been drawn to the subject, and as a result many measures of value have been introduced. Much progress has been made by extensive medical researches, and this, combined with the information gained by its application to working conditions clearly indicates the precautionary measures which should be applied to those industries not already provided for by Government regulations.

ARTIFICIAL PRECIOUS STONES.

By NOËL HEATON, B.Sc., F.C.S.

(*Continued from page* 81.)

CRYSTALLOGRAPHERS are agreed that each boule is a single crystalline individual, with the major axis roughly perpendicular to the plane of formation—that is to say, running from the point of attachment of the pedestal to the top of the mass. On the top of the boule one invariably finds a mass of symmetrically-arranged facets, which Dr. Herbert Smith has found to correspond with the fundamental rhombohedron of corundum. Judging by analogy with other materials, one would expect at first sight that a fused mass formed in this way would be either a heterogeneous mass of minute crystals, or entirely amorphous, possessing the structure characteristic of glass. It is well known, for example, that under similar conditions pure silica yields "quartz glass," which is extensively manufactured at the present time.

Then, again, there is the matter of colouration. One would like very much to know what is the state of combination of the chromium in a ruby, and whether the colour is produced by chromium aluminate in solution or metallic chromium in molecular suspension. In glass, as is now well established, this colour is produced by the optical effect of ultra-microscopic spheres of metallic gold or copper, but there seems to be no parallel between the two cases. A point of more practical interest is the fact that although the artificial corundum is a true crystal it possesses the shape and formation of a congealed liquid or glass. The practical interest of this lies in the fact that it affords the only means of distinction between this artificial corundum and the naturally-formed gem-stone.

In the latter, any foreign matter which may be present is coerced into following the lines of growth of the crystal, and more particularly bubbles of gas which may be present in the liquid are distorted from their natural shape so as to accord with this symmetrical growth. It is the great exception to find a natural ruby entirely free from such inclusions, which generally form irregular cavities with a decided tendency to geometrical shape.

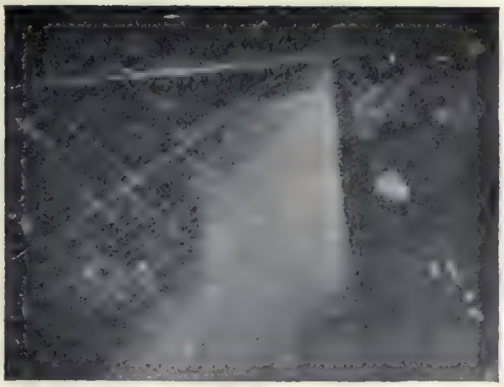

FIG. 3.

It is very common also to find the structure technically known as "silk" caused by microscopic bubbles drawn out into a series of parallel canals, all being in one plane following one of the axes of the crystal. Any variations of colour in different portions of the stone also follow the lines of growth in this manner. (Fig. 3.)

In the artificially-produced corundum, on the other hand, although the particles arrange themselves symmetrically, any air bubbles that are entangled in the successive globules remain undisturbed, and appear as naturally spherical bubbles in the finished product; and, moreover, if one globule differs slightly from another in the proportion of chromium, the resulting difference in colour follows the form of the mass as a whole, the zones of colour being circular. (Fig. 4.)

The Silicate Group.

As regards those transparent gem-stones, which fall into a group by reason of the fact that they contain silica as an essential component, their artificial production is of little importance. They cannot be produced by the same process as corundum, owing to the fact, already alluded to, that under such conditions both pure silica and compound silicates yield an amorphous product, which has not the optical properties of the natural stone. One is constrained, for the artificial production of the crystalline material, to fall back upon methods similar to those employed in the earlier attempts to obtain ruby—obtaining the requisite composition by chemical reaction and maintaining the mass at a temperature just above its fusion point for a sufficient time to allow the silicate to crystallise out.

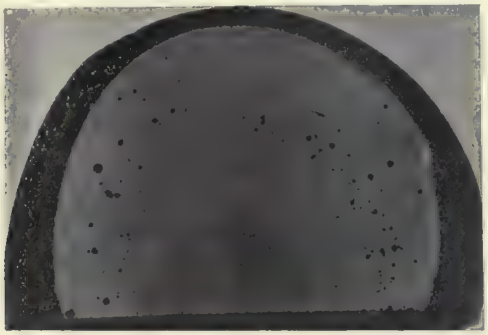

FIG. 4.

Topaz, garnets, and zircon have been produced in this way experimentally as a matter of scientific interest, but the small stones produced have no commercial value, and to describe their production in detail would only weary you to no purpose. The majority of these stones are of such common occurrence in nature, and consequently of such little value, that their artificial production in this manner is not a commercial proposition.

An exception, however, must be made in the case of emerald, which ranks next in value to corundum, and many attempts have been made to produce it artificially. Reconstructed emeralds have been made by the Verneuil process, but these are, of course, amorphous, and do not possess the double refraction and other properties consequent upon the crystalline structure of the natural stone. In fact, the problem of producing this stone artificially has not as yet been solved.

Opaque Stones.

As regards the opaque stones, the artificial production of turquoise was successfully accomplished many years ago, by precipitating hydrated phosphate of aluminium with the requisite proportion of copper phosphate to give it the colour, and subjecting the precipitate whilst still damp to hydraulic pressure for a considerable time. Prepared in this way the artificial turquoise is so nearly identical with the natural product that its identification is a matter of considerable difficulty.

The opal ranks with the diamond in resisting attempts at artificial production, and is even superior to it, in that it cannot be really successfully imitated.

The peculiar lustre of the pearl, like the colour of the opal, is due rather to its structure than its composition. It is formed in the oyster by the deposition of successive layers of calcium carbonate round some central object, and consists of an innumerable number of thin overlapping laminæ of the crystalline variety of this substance known as aragonite, as can be seen from the section (Fig. 5). These layers being semi-transparent, the light falling on the surface is partially reflected from the surface and partially transmitted into the stone, where it suffers reflection from the surface of lower layers.

To produce this complicated structure artificially is practically impossible, unless one can describe as an artificial pearl that formed by the oyster in response to the deliberate introduction of irritant foreign matter by human agency. Perhaps the well-known Japanese pearl may be correctly described as artificial pearl, although the oyster has a great deal to do with it. Such pearls are formed by introducing a mother-of-pearl shape between the shell and mantle of the oyster and then leaving the oyster alone for a time to allow it to convert this into a pearl by the deposition of several layers of nacre. The mass is then removed from the shell and converted into the semblance of a true pearl by supplying a back of mother-of-pearl. Such pearls, however, never have the fine orient of those produced under normal conditions, and they can readily be detected by examining the back, when the lustreless mother-of-pearl and the line of junction can be detected.

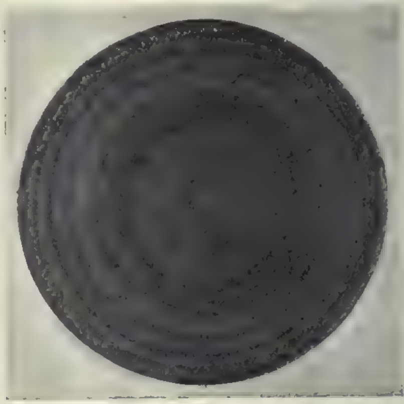

FIG. 5.

SMOKE ABATEMENT.

By John B. C. Kershaw, F.I.C.

Two events are occurring during the present year which mark the completion of a further stage in the Smoke Abatement campaign in this country, and render the moment opportune for discussing the progress of the movement from the point of view of the chemical engineer.

In the first place, an International Exhibition of Smoke Abatement appliances was opened in the Agricultural Hall, London, on the 23rd of last month, and is to remain open 14 days. The last International Exhibition of this character was held in 1881, so that there has been no undue haste in promoting another.

Mr. F. W. Bridges is acting as Organising Manager of the Exhibition, which is being held under the auspices and supervision of the Coal Smoke Abatement Society. Among the large number of public bodies and societies supporting the Exhibition are:—

The Association of Engineers-in-Charge.
The Chief Officials of London Electric Supply Companies.
The Chemical Society.
The Institute of Chemistry.
The Institution of Electrical Engineers.
The Institution of Gas Engineers.
The Institution of Heating and Ventilating Engineers.
The Institution of Mechanical Engineers.
The London Chamber of Commerce.
The Royal Institute of British Architects.
The Royal Meteorological Society.
The Royal Sanitary Institute.
The Surveyors' Institution.

The Duke of Argyle is acting as President of the Exhibition; the list of Vice-Presidents includes the names of Sir William Crookes, F.R.S., Sir Oliver Lodge, F.R.S., Sir William Preece, F.R.S., Sir William Ramsay, F.R.S., and the Right Hon. Lord Rayleigh, F.R.S.

With this backing and support from scientific Societies and many of the foremost scientific men of the day, the London Smoke Abatement Exhibition of 1912 ought to prove a striking success, and it is hoped that it may result in a considerable impetus to the whole movement for securing mitigation of the nuisance and damage from black smoke, not only in London, but in all large centres of population and manufacturing industry.

A Conference of all interested in the subject is to be held during the second week of the Exhibition, and a large number of interesting papers on various aspects and departments of the work now being carried on, have been promised.

The second important event relating to Smoke Abatement which will occur this year, is the promotion in Parliament of a Bill to amend and consolidate the various local Acts, now enforced against smoke nuisance in this country. The Council of the Smoke Abatement League of Great Britain are promoting this Bill, and Mr. Gordon Harvey, M.P. for Rochdale, has consented to act as its political sponsor, when it comes before the House of Commons.

The main provisions of the Bill relate to the constitution and duties of the Local Smoke Prevention Committees, which are to be appointed by the Local Government Board, for the express purpose of enforcing the provisions of the new law. This law is to be uniform for the whole of the country. The Local Committees will appoint local Smoke Inspectors, who will be dependent as to one-half of their salary upon the Local Authority, and as to the other half, upon the Local Government Board. By this means it is hoped that the Smoke Inspectors will be relieved from domination by the Local Authority, and will gain in efficiency. District Smoke Inspectors, whose appointment, position and responsibilities would be similar to those of the Alkali Inspectors, would keep the Local Committees and Inspectors up to their work, and would prevent the inadequate enforcement of the law which is now too common in certain districts and localities.

The minimum fine for offences is also to be increased, and the fines are to be made cumulative for repeated offences under the Act.

The writer has stated elsewhere his belief that an Amended Act on these lines will be passed sooner or later.[1] It may be doubted, however, whether public opinion is yet sufficiently educated on this subject, to supply the necessary driving force for pushing such an Act through the present Parliament. Even if it were, the Cabinet has so many large schemes of reform in hand, and has so fully mortgaged in advance the time of Parliament, that no measure of this character, unless treated as a non-controversial Bill, could hope to pass the Committee Stage of its progress through the House of Commons. For these two reasons, it is improbable that there will be any change or modification made in the English law relating to Smoke Emission, either this year or next.

The attitude of the chemical engineer towards the Exhibition and Conference, and towards the proposed legislation, cannot be anything but friendly. The combustion of solid fuel for the purpose of generating heat is, after all, a chemical process, and the writer is convinced that had this been recognised by manufacturers years ago, and had the boiler and heating installations in all large works been placed under the control of the chemical staff, the nuisance arising from the emission of excessive smoke by factories, would have been to-day largely non-existent.

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[1] "Local Government Review," February, 1912.

The statement made at the London Smoke Abatement Conference of 1905, by the representatives of a well-known North Country firm, that since the steam-raising and heating plant in their works had been placed in charge of a specially qualified chemist, their savings had been equivalent to 1,000 tons of fuel per week, or £25,000 per annum, was no doubt an exaggerated estimate of their gains; but it served its purpose, and attracted much attention at the time. That more scientific control of boilers and furnaces is advantageous, both as regards the reduction of black smoke and the saving of fuel, is now being slowly grasped by works managers and factory owners, and in the majority of large works an Engineer with some knowledge of the chemistry of combustion, is placed in charge of the steam-raising and heating plant. Whether better results would not be obtained by following the example of the firm already alluded to, is a question which will only be decided by actual experience. The prejudice which so many manufacturers have against scientific control of their boiler plant, is partly due to their own ignorance of the chemistry of the combustion process, and partly to the fact that the early attempts to secure smokeless combustion of fuel for steam-raising purposes, were allied with the use of a large excess of air and a greatly diminished efficiency of the whole plant. The large number of valueless, and even absurd appliances and methods which have been patented and tried as remedies for boiler smoke, proves to what an extent the factory owner has suffered from his own lack of knowledge. However, this method of learning wisdom, though expensive, is generally effective. It is satisfactory to note that, thanks to the combined influence of the ignorant inventor, and the Exhibitions and Conferences which have been held in the larger provincial cities and centres of manufacturing industry in recent years, the British manufacturer is at last beginning to realise that smoke prevention under scientific management, is in nearly all cases allied with fuel economy, and that a well-designed and well-managed steam-raising or heating plant, *if not overworked*, can be relied on to produce little or no smoke.

Concurrently with this education of the factory owner, there is proceeding a no less important education and training of the stoker, who actually burns the fuel. An efficient and well-designed plant is of little use without efficient workers to operate it, and one of the difficulties in this country in the past, has been the lack of properly trained and qualified men for this work. It is unfortunate that the "stoking" of steam-boilers and heating appliances generally, should have been regarded by employers and managers as work which any man who could handle a shovel was qualified to undertake, and that the wages paid for it were little above the level of those paid to the casual day labourer. The result has been that the boilers and furnaces in many works and factories are still fired or controlled by a very ignorant and badly-paid class of labour. The second step in the reduction of smoke and saving of fuel must be, therefore, to educate the firemen themselves in more correct methods of firing, and to increase their pay and make it a more adequate return for the highly important work they perform.

Classes for the instruction and training of stokers and boiler engineers have been held in London, Glasgow, Manchester and Liverpool, with good results in recent years, and it is hoped that this method of attacking the black smoke problem will be generally adopted.

It has not been the writer's purpose in this article to discuss the scientific principles of smoke less combustion, or to describe the methods by which these principles can be applied in the construction and working of the furnaces of steam-boilers, or other heating appliances. He has only attempted to indicate the lines upon which progress is occurring, and to point out, that as combustion is a chemical process, the chemical engineer must be more and more relied on for co-operation in the work of securing clearer skies and a purer atmosphere.

Fuel Losses.—"There are large numbers of works in this country connected with the glass, chemical, and metallurgical industries in which incalculable amounts of coal are wasted every year through bad usage of good construction. The introduction of the Siemens regeneration furnace was the beginning of a revolution in methods. It is universally used for glass-making, and should not require more than 12 cwt. of coal per ton of melted glass. Factories are known to the writer where the consumption is never less than, and often exceeds, three times this amount, nothwithstanding the use of a complete Siemens plant."—*Times.*

* * * * *

Electric Steel.—Messrs. Vickers are erecting an 8-ton Heroult furnace at Sheffield, as a result of a 2½ ton furnace trial which has been running for a year. The new furnace is a three phase one, the first one of this kind to be used in this country. It is expected to have an increased efficiency of 15%. The Deutscher Kaiser Works are putting in a 25-ton furnace. The quality of Bessemer basic steel is such, that it is expected to be replaced unless it can be saved by a short electric refining process. This matter is particularly important to Germany.

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Volatility of Platinum.—Sir William Crookes has brought before the Royal Society the results of some experiments which indicate that platinum is volatile below its melting point. At 1,300°C. a platinum crucible lost 0·245% of its weight. Palladium lost 0·745%, and iridium 7% after 22 hours' exposure. At 900° platinum lost no weight, but palladium lost 0·09% in 10 hours and iridium 0·09 in 20 hours. In a vacuum at 1,300°, iridium volatilised to an appreciable extent with condensation in the cooler portion of the quartz tube.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

PROGRESS OF BIO-CHEMISTRY.

Synthesis by Enzyme Action.

By A. Harden, D.Sc., F.R.S.

Since Croft Hill's memorable work on "Reversible Zymohydrolysis," by which the fact of synthesis by enzyme action was first established, a large amount of experimental evidence has accumulated, dealing with the reversibility of hydrolytic decompositions effected by enzymes. A typical and simple example of this most important class of bio-chemical changes is afforded by the relations of emulsin to arbutin on the one hand, and to quinol and glucose, into which arbutin is resolved by hydrolysis, on the other. Under ordinary circumstances, in aqueous solution, the arbutin is almost completely decomposed by emulsin. When, however, a considerable proportion of the water is replaced by glycerol, and emulsin is added to a solution of quinol and glucose in the resulting medium, it is found that a certain proportion of arbutin, by the change in rotation, is produced, and that at the same time a glucoside of glycerol is formed. When the solution, after having attained this condition, is diluted and some fresh emulsin added to keep the concentration of the latter constant, the glucosides which have been synthesised are decomposed into their constituents. So little complicated is the matter by unknown factors, that this reaction is recommended by Bayliss as a laboratory exercise for students.

Although, however, the fact is certain and universally admitted that such syntheses do occur, a cloud of controversy has gathered about the interesting question of how they are brought about. The orthodox view, ably championed in this country by Bayliss, is that enzymes, being catalysts, accelerate alike the reactions leading to the decomposition and to the formation of the compound in question, and thus merely diminish the time in which the condition of equilibrium is reached, but do not at all, or not materially, alter the position of this equilibrium. Hence, given hydrolysis by an enzyme, synthesis follows as a logical necessity, when suitable conditions are employed.

On the other hand, from the very beginning, experimental anomalies have been found which have led to diverging opinions on the subject.

Croft Hill himself, by the action of maltase on glucose, obtained not only, or even chiefly, maltose, but the isomeric isomaltose, and E. F. Armstrong, following up Croft Hill's work, has obtained even more paradoxical results, which have led him to express the view that maltose and emulsin synthesise the very sugars (isomaltose and maltose) which they are respectively unable to hydrolyse. According to this view, therefore, the powers of hydrolysis and synthesis are separate properties, independent of each other.

A further step towards the complete dissociation of the hydrolytic and synthetic properties of enzymes has been taken by Rosenthaler, who claims to have separated the enzymes which respectively hydrolyse and synthesise benzaldehydecyanhydrin and to have obtained a preparation which will effect the synthesis only, and not the hydrolysis. This idea has found acceptance with several workers, and Euler has even gone so far as to suggest a nomenclature whereby the synthetical enzymes are distinguished by the termination-*ese*, from the enzymes causing decomposition, which, according to the usual practice, are known by the termination-*ase*. In view of the doubt which exists as to the actual existence of separate analytic and synthetic enzymes, this proposal must be regarded as premature. An incidental disadvantage is that the German name for one class of enzyme sounds almost exactly like the English name for the other.

One of the arguments in favour of the separation of function is that Beitzke and Neuberg by injecting emulsin into a rabbit, obtained a serum which they considered to be capable of synthesising lactose from glucose and galactose, but not of hydrolysing it, a fact which they explained by supposing that the emulsin, itself capable of hydrolysing lactose, had induced the formation in the rabbit serum of an anti-emulsin, capable only of synthesising lactose.

Bayliss has recently repeated these experiments, and his results, published in the current number of the *Journal of Physiology*, are in complete disagreement with those of Beitzke and Neuberg. The serum obtained was incapable of synthesising lactose, and the inhibiting effect which it produced on emulsin was entirely due to its alkaline reaction, and was produced in equal degree by normal serum. No evidence of the production of an anti-emulsin was therefore obtained, and until some further confirmation of Beitzke and Neuberg's results is forthcoming they cannot be regarded as well-established. Euler regards the production of hexosephosphate from sugar and phosphate in yeast-juice as another instance of the isolated synthetic action of an enzyme. Harden and Young have, however, shown that the formation of this substance is due to a reaction which also involves the decomposition of sugar into alcohol and carbon dioxide, or into some unknown precursor of these, and it is very improbable that the reversion of such a reaction could be observed, except under very special conditions.

It will be seen that the evidence in favour of the existence of specific synthetic enzymes is by no means strong. The question is one of great interest and importance, and affords a field for work which will doubtless attract much attention in the immediate future.

THE MECHANICAL AND CHEMICAL EFFECTS OF WATER ON CLAY.

By Walter C. Hancock, B.A. (Cantab), F.I.C.

Water exerts a very important influence on the properties of clays. In the natural state clays contain water in two forms, mechanically combined as moisture and also chemically combined with some of the constituents. An ordinary air-dried clay carries about 1 to 3 per cent. of the former, but the amount of the latter may be as much as 14 per cent. Increasing amounts of water, added to an air-dried clay, produce a series of changes in its behaviour, though the whole series may not be complete in any one specimen. The first change is that of mechanical disintegration, for in many cases, when lumps of clay, as won from the mine, are sprinkled with water, the pores of the lump, previously filled with air, are penetrated by the water and the whole lump falls more or less to pieces, in much the same way as a lump of burnt lime. The phenomena are so similar that the term "slaking" has also been employed to describe this action of clays, though, of course, in the latter case no chemical combination is involved, as in the hydration of caustic lime. The action is generally more rapid and more marked with "mild" or plastic clays and is increased by the use of hot water. In many cases 5 to 10 per cent. of water is sufficient to produce the effect, but it is by no means universal, for some clays may be actually immersed in water for a long time and still retain a hard rocky character.

After a clay has been disintegrated by water, grinding or both, and more water is added to it, the mass becomes crumbly, but though the particles cohere loosely it cannot be moulded. In order to bring the mass into a suitable condition for moulding the quantity of water must be increased until it has no tendency to be sticky when rolled in the hands, though a comparatively slight deficiency or excess of water may produce stickiness. For the condition of maximum plasticity the ratio of water to dry clay is very constant for any particular clay, but varies widely with different varieties; this ratio calculated as a percentage is in fact often used as a measure of the plasticity. As the amount of water is increased beyond this limit the mass gradually passes into the form of a thick paste or "slip," and as such is employed in the process of "casting" ceramic articles. At different stages in the addition of water the mass shows two properties, namely, cohesion and plasticity. When the individual grains are only partially coated with films of water the mass merely coheres loosely, but when the films are complete the cohesion of the whole mass is increased, and the films act as lubricating surfaces for the movement of the grains relatively to one another. When the thickness of the films is sufficient to overcome the attraction of the grains for one another their range of movement is increased, and the mixture acquires the character of a fluid.

Moulded or cast clay articles, on exposure to the air, gradually lose the water added for tempering in the form of vapour, and in a thoroughly air-dried condition retain about one or two per cent., which can be removed by heating to 105°C. The quantity of this tempering water is rather surprising when it is remembered that a ton of tempered clay, which requires 30 per cent. of water, gives off about 6 cwt. during drying. A detailed description of the physical changes in the mass during drying would be beyond the scope of the present article, but the subject cannot be dismissed without a reference to one of the essential properties on which the industrial application of clays depends, namely, the rigidity of the moulded articles, and the strength developed, for the tensile strength may range from a few up to perhaps 300 lbs. per square inch.

Apart from the water thus held mechanically in the clay, there is, however, another form to be considered, namely, that chemically combined, the bulk of which is contained in the hydrated aluminium silicate or "clay substance." Le Chatelier has shown that the removal of this chemically combined water is accompanied by a marked absorption of heat. This absorption of heat occurs at different temperatures with different hydrated minerals, which can be divided into classes on this basis. In the case of kaolin the dehydration begins at about 550°C. and is complete at about 650°C. This phenomenon, observed on a laboratory scale, was confirmed on a large scale during the burning of a down-draught kiln containing some 27 tons of fireclay goods. The temperature of the kiln was measured by means of a thermo-couple, suspended from the crown of the kiln, and at about 500°C. no rise of temperature occurred for 32 hours, although the fires were regularly increased during that period, indicating that there was an absorption of heat due to the physical change of dehydration. At the end of the time the temperature rose steadily, and the cooling curve of the kiln showed that the fall of temperature was unbroken.

Clay which has been dehydrated has no plastic properties when mixed with water, though it is capable of absorbing water mechanically, and up to the present no industrial method has been devised by which burnt clay can be re-hydrated.

ELECTRO-CHEMISTRY.

Action of Organic and Inorganic Substances in the Bath.

By F. Mollwo Perkin, Ph.D., F.I.C.

It is well known that the addition of certain organic and inorganic substances to an electrolyte, usually substances of a colloidal nature, causes the deposited metal to be denser and smoother. The formation of nodules, "trees," and so on, is also minimised. One of the difficulties in the commercial deposition of copper is "treeing." This, in practice, causes it to be necessary to keep the anode and cathode plates further apart than otherwise would be the case. Furthermore, continual inspection is necessary in order that should trees form they may be removed.

It was Sir Joseph Swan who first showed that the addition of a little glue or gelatine to the bath greatly improved the density and smoothness of the deposit of copper and allowed the employment of higher current densities. Many electrotypers now employ small quantities of organic "addition agents" in order to work with high current densities. Organic substances can hardly, however, be employed in the enormous copper refineries. As it is a question of refining, the crude anodes as they dissolve are continually causing contamination of the electrolyte, one of the most objectionable substances being arsenic.

Messrs. Ching Yu Wen and E. E. Kern[1] have published a long paper on the action of "addition agents" and impurities on the Electrodeposition of Copper. Their work may be grouped under four headings: (1) Impure electrolytes which contained no "addition agents"; (2) Impure addition agents which contained inorganic "addition agents"; (3) Impure electrolytes which contained organic "addition agents"; (4) Impure electrolytes which contained both inorganic and organic "addition agents."

When the electrolytes contained as little as 1·5 per cent. of arsenic and antimony, it was found that without addition agents these impurities were deposited along with the copper. Still larger quantities were deposited when the arsenic and antimony amounted to 2 to 3 per cent., and large "trees" were formed on the surface. The appearance of the copper was dull, and it was also brittle.

On the other hand, at temperatures of from 50° to 60°C., and with electrolytes which contained more than 6 per cent. of arsenic, the arsenic acid had the effect of an addition agent, and, to some extent, prevented the deposition of impurities such as arsenic itself, and antimony;

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[1] *Trans. Am. Electrochem. Soc.*, 20, 120.

the formation of trees is also retarded. At temperatures below 40°C. the action of arsenic as an "addition agent" in the electrolyte did not appear to take place unless there was present at least 8 per cent. The addition of arsenic consequently depends upon the temperature of the electrolyte and the quantity of arsenic present.

It was also found that when present in small amounts the following inorganic substances caused distinct improvement in the character of the deposited metal, which was smoother, denser, purer and freer from "trees": Hydrochloric acid, cuprous chloride, cupric chloride, sodium chloride, aluminium chloride, aluminium sulphate, sodium sulphate, sodium nitrate, sodium borate, sodium chlorate. The best and most effective of these inorganic agents is sodium chloride, the next best being hydrochloric acid and cupric chloride. It is a little strange that while aluminium sulphate is a fairly good addition agent, rendering the deposit pure and quite ductile, aluminium chloride is not suitable.

It appears from these results that the best "addition agents" are salts of metals which are much higher in the E. M. F. series than copper. They appear to possess the property of preventing, or at any rate, retarding the deposition of arsenic and antimony and preventing "tree" formation. The higher the metal of the addition agent stands in the E.M.F. series, the purer, smoother, and less brittle the deposit which is formed. The explanation given is that there is a reducing effect by the metallic ions which are carried to the cathode by the passage of the current and thus form a menstrum round the cathode, and that this menstrum has the property or power of changing the copper crystals to an amorphous form.

The facts are interesting, but the explanation does not carry us very far forward.

In the case of organic addition agents, gelatine, glue and tannin produced marked beneficial effects. Peptone, on the other hand, has a detrimental action, and causes rough, non-coherent and impure deposits.

The deposits of copper obtained from electrolytes containing the combined "addition agents" were in all cases satisfactory. This was particularly the case with combinations of gelatine and sodium chloride, glue and sodium chloride, and glue and cupric or cuprous chloride. The most satisfactory of all was gelatine and sodium chloride.

Sodium chloride was in all cases the best inorganic addition in combined "addition agents," as it always produced a good, smooth and ductile copper. Sodium is, of course, very highly electro-positive, and from this point of view, from what has already been stated should be most satisfactory. Potassium chloride appears not to have been tried. Apart from the positive ion the chlorine ion seems to exert the most beneficial action. It seems to counteract or improve poor or bad action of an organic "addition agent." For example, it has already been mentioned that peptone is not satisfactory, but copper deposited from solutions containing a combination of peptone and sodium chloride or hydrochloric acid improved both in physical character and in purity.

Both from the purely scientific and also from the commercial side, such experiments as we have just referred to are of great value. Of course, in obtaining a satisfactory deposit there are many other factors of importance, such as good circulation of the electrolyte, the current density, the temperature, the concentration of the solution in copper sulphate, and the acidity. In the experiments above, the current density appears to have been 40 amps. per sq. foot all through. In electrotyping practice it is not unusual to go up to 100 or more. On the other hand, in ordinary refining work 40 amperes is good practice, and we take it the authors were considering this aspect of the question.

RUBBER AND ITS CULTIVATION.

By Clayton Beadle, and Henry P. Stevens, M.A., Ph.D., F.I.C.

The attention recently directed to this material, not only by the technologists but by the general public, has originated in the exploitation of new sources of production of the raw material rather than in new lines for its development and utilisation. Consequently, in the present article, we shall be rather more concerned with the raw material than with its products. The recent developments in the production of the raw material have taken place in two directions. The first, we may term the sylvicultural; the second, the synthetic. The former has developed very rapidly, while commerically it is hardly more than five or six years old. In 1905, the total export of rubber from the East only amounted to somewhere about 150 tons, whereas for 1911 it exceeded 14,000 tons—roughly, say one-sixth of the total world's production, and is still rapidly advancing. The synthetic is technically in its infancy and commercially as yet non-existent. But it is, at the present time, a field in which much research is proceeding, and within the last year or two caoutchouc has been synthesized by more than one novel series of re-actions.

Before proceeding further, it may be as well to say a word as regards nomenclature. By "raw rubber" is understood the solid product carrying a proportion of impurities derived from the nitrogenous or mineral constituents in the latex, impurities absorbed in the process of curing, and a larger or smaller proportion of moisture. By "caoutchouc," we understand the essential rubber substance, the hydro-carbon of the empirical formula C_5H_8, which occurs in the latex in the form of minute globules, suspended in a mother liquor containing other constituents —especially resinous matters. "Vulcanised rubber" is the raw rubber suitably washed and dried and subsequently subjected to a manufacturing process by which minerals and other ingredients may be incorporated, and also in which a chemical or partly chemical, partly physical, re-action takes place by which sulphur (and in some cases, chlorine) becomes intimately associated and probably chemically combined with the caoutchouc.

In the early days, various species of trees were planted, all of which yielded a latex relatively rich in caoutchouc. Of these the more important are the *Hevea Braziliensis* or *Para* rubber tree, the *Castilloa Elastica,* the *Rambong* or *Ficus Elastica,* and the *Ceara* or *Manihon* rubber trees. These trees in an uncultivated state form the main sources of the raw rubber that is produced. If we include the *Funtumia Elastica* and the various *Landolphia* species we have all the main sources for the production of the better grade rubbers. However carefully the latices of these various trees be prepared and the raw rubber purified, the result—caoutchouc—is neither chemically nor technically pure. It is always intimately associated with two or three per cent. at least of (1) resinous matters, (2) nitrogenous matters, the greater part of which latter are probably of the nature of protein. When the rubber latex is coagulated these substances are also precipitated. It is, however, possible in some cases, by varying the nature of the coagulant and the process of cure, to modify both the quantity and nature of the protein constituents, as also to reduce the proportion of the resinous matter; but whatever process be adopted, it has not so far proved possible to obtain a commercial raw rubber free or practically free from these constituents. The majority of raw rubbers also contain small quantities of mineral matters largely potash. By careful preparation, however, these may be practically eliminated, and rubber is now being produced commercially yielding less than ·1% of ash. Three-quarters or more of the plantation-produced Para rubber is practically dry. The loss on drying does not usually exceed 0·5% in the best prepared rubbers of this class. Whether, however, the loss observed on drying is entirely due to loss of moisture has not as yet been ascertained.

It will be gathered then that raw rubber can be produced in quantity practically free from moisture and mineral matters, but containing two or three per cent. each of resins and nitrogenous matters, assuming this latter to be of the nature of protein. This assumption is probably correct as regards the greater portion of the nitrogenous matter and arises from the method of coagulating the rubber. Almost any acid re-acting substance taken in the right proportion will coagulate *Hevea* latex, and only a mere trace of the stronger organic and inorganic acids is required. The process was regarded by the older school as a precipitation of the protein which was supposed to surround the caoutchouc globules as a skin. Certainly about half the nitrogenous matter in the latex is rendered insoluble during coagulation. The more modern school discards the protein precipitation theory and talks of negative emulsions. The latex globules are regarded as charged, and the addition of kations in any form brings about discharge and coagulation. The matter, however, is not so simple. Latex, regarded as a colloidal solution or an emulsion, behaves abnormally. Thus, for instance, V. Henri showed some time ago that the addition of weak solutions of common salt to *Hevea* latex caused cessation of Brownian movement without coagulation of the rubber. Freundlich hardly credits the statement or, at any rate, thinks that two or more globules must coalesce under these conditions, and that Brownian movement ceases on account of the firmation of individual globules or particles of increased size. We have, however, observed the same cessation of Brownian movement by adding small quantities of dilute calcium chloride solution or weak acetic acid to diluted latex, the amounts added being smaller than those required to produce coagulation. Freundlich's explanation is untenable. In the first place globules of *Hevea* latex do not readily join up and fuse into one another like drops of oil. In this respect *Hevea* latex differs completely from many other latices. Secondly, if the globules had increased in size this could not have escaped notice when the latex was under observation.

It is probable that after all the protein or other nitrogenous matter plays an essential part in the coagulation phenomenon. We no longer speak of the skin of protein surrounding the globules but of adsorption on the surface of the globules, and this adsorbed material is considerably modified by the addition of the acid. It is obvious that if rendered insoluble the protein must be retained in the raw rubber however thoroughly the latter be washed, and should be separable by an organic solvent, such as benzene, in which the rubber swells up to form a colloidal "solution." Long ago it was noted that raw rubber contained a so-called "insoluble constituent," and this was separated from fine hard Para and analysed with much pains by the earlier observers. As in another classical instance, these investigators failed to detect the essential element, in this case, nitrogen, contained in the insoluble matter, and consequently went a good deal astray in theories based on the supposition that they were dealing with an oxidation produce of the hydrocarbon. Spence first showed that the "insoluble constituent" of Para rubber was highly nitrogenous, and there is little doubt but that it represents the nitrogenous latex constituent rendered insoluble in the process of coagulation. Some plantation rubbers, such as pale crepe, a rubber which has been very thoroughly washed after coagulation, "dissolve" very readily in benzene, and might be thought to contain no "insoluble constituent" as the solution looks clear. Nitrogen, however, is present, as can be shown by analysis of the rubber, and after a time a deposit begins to form and an insoluble substance settles out on the bottom of the containing vessel. This has been described as a mere flocculation, a tendency to which is shown by some colloidal solutions. In this case, however, the substance that settles out is rich in nitrogen, and the solution above is poorer.

It is a fortunate circumstance that the *Hevea* or Para rubber tree not only yields the best rubber but is the best suited for economic cultivation, and, whereas a few years back other varieties were planted, no one to-day thinks of planting any species but *Hevea*. Confining our attention now to Para rubber, an interesting comparison may be drawn between the technical value of the production of the plantations with that obtained from the forests of Brazil. The latter has always been regarded as the finest rubber in the world, and used to fetch the highest price per unit of caoutchouc. It must be remembered that the commercial article loses 15 to 20% of its weight on washing and drying, while the plantation rubber is technically clean and dry in the form in which it is exported.

It has been found that raw rubbers of different botanical origin behave differently under manufacturing conditions, particularly with regard to vulcanisation. This difference of behaviour is now easily defined in set terms, but is at once apparent to anyone who has worked with different raw rubbers. And the question at once arises as to how far this difference in behaviour is connected with the different proportions or different nature of the resinous and protein constituents. At the present time there is very little evidence on this subject. We have ourselves carried out experiments, extracting raw rubbers with solvents previous to vulcanisation and noting the effect on the behaviour of the rubbers. Unfortunately however, the extraction with solvents, such as acetone or alcohol, even if carried out in the cold, has some remarkable effect on the caoutchouc itself, so that rubber so treated is technically inferior, and when physically tested gives lower figures than the untreated rubber, although the percentage of resin may have been very materially reduced. This remark applies to relatively high-grade rubbers such as we are considering at the moment. Obviously, where the solids separated from the latex contain 50% or more of resinous matter, the whole question assumes a different aspect. We are inclined to think, however, that the difference in technical value of the various raw rubbers can only be attributed in part to the proportion of resinous and nitrogenous matter. The relative quality of rubbers of different botanical origins does not appear to bear any close relationship to the proportions of these resinous and nitrogenous constituents. Thus, of the various rubber-yielding trees that have been cited there is little doubt but that the rubber obtained from the latex of the *Hevea Braziliensis* stands in a class apart from, and superior to, the others. It also contains a very low percentage of resin. The only rubber which behaves similarly under vulcanising conditions is the *Ceara*. This, however, contains a relatively large proportion of resins.

(*To be continued.*)

SOOT: ITS CHARACTER AND EFFECTS.

By J. B. COHEN, B.Sc., Ph.D., F.R.S.

SOOT consists mainly of carbon, tar and ash, or mineral matter, together with small quantities of sulphur, arsenic and nitrogen compounds, and it generally possesses an acid character.

When one considers the varying conditions under which coal is burnt, it is obvious that the character of the soot must vary. For soot is a product of incomplete combustion, and is formed partly by the mechanical removal of dust by the chimney draught and partly by the decomposition of the fuel, such as occurs in the process of destructive distillation. It might, therefore, be expected that the higher temperature and stronger draught of a factory furnace would produce a soot more by mechanical removal and less by incomplete combustion than a domestic grate; in other words, a soot containing more ash and less tar. Not only is this the case, but the soot varies in character with the distance from the grate at which it has been deposited. Still another factor, which will influence the character and composition of the soot, will be the kind of coal used.

The following analyses illustrate these facts very clearly.[1] In the case of the soots obtained from the Leeds University, the same coal was burnt in an ordinary fire grate, the flue of which had been previously swept, and also in a boiler furnace attached to a chimney 110 feet high :—

ANALYSES OF SOOT FROM THE UNIVERSITY.

	Coal.	Domestic Soot.	Boiler Soot.		
			Base.	70 ft. up.	Top, 110 ft.
	per cent.	per cent.	per cent.	per cent.	per cent.
Carbon	69·30	40·50	16·66	21·80	27·00
Hydrogen	4·89	4·37	0·86	1·44	1·68
Nitrogen	1·39	4·09	0·00	1·18	1·21
Ash	8·48	18·16	75·04	66·04	61·80
Tar	1·64	25·91	0·09	0·80	1·66
Sulphur	1·74	2·99	2·67	2·58	2·84
Chlorine	0·27	5·19	0·11	1·46	1·60
Arsenic	0·097	—	0·078	—	0·120
Acidity (as H_2SO_4) ..	0·00	0·37	1·33	0 58	0·56

The differences between the domestic and boiler soots, thus obtained from the same coal, are striking and instructive. The sample from the base of the boiler chimney is little more than flue dust; practically all the hydrocarbons have been burnt, while the few that have volatilised at the high temperature have no chance of recondensing. Farther up, the more volatile constituents, ammonium chloride and sulphate, and the arsenic accumulate. The sample of domestic soot is typical of all those which have been analysed, by reason of its high content of tar and volatile substances and low content of ash. The amount of tar may even reach 40 per cent. under certain conditions. The following analyses were made of soot from the flues of a house in which a good quality of Yorkshire coal was burnt :—

DOMESTIC SOOT.

	Coal.	Soot from Kitchen	Soot from Dining Room.		
			10 ft.	20 ft.	35 ft.
	per cent.	per cent.	per cent.	per cent.	per cent.
Carbon	76·8	52·3	36·5	34·1	37·2
Hydrogen	4·9	3·7	3·5	3·5	3·5
Nitrogen	1·72	4·11	6·89	6·04	5·05
Ash	1·80	17·80	5·09	4·97	4·94
Tar	0·88	12·50	34·9	37·2	40·4
Sulphur	0·79	2·20	2·18	2·56	2·45
Chlorine	0·25	1·35	9·07	6·41	4·96
Arsenic	—	—	0·0016	0·0042	0·0013
Acidity	0·00	0·28	0·92	0·55	0·92

It will be noticed that the higher temperature of the kitchen fire and the stronger draught increases the amount of ash and lowers the percentage of tar and volatile products as compared with the more sluggish combustion in the dining-room.

Of the actual amount of soot emitted from factory chimneys, it is clearly impossible to obtain trustworthy data. It will vary with the quality of the coal, the size and structure of the chimney, and the method of firing. Scheurer-Kestner, in a very careful and elaborate research on flue gases from boiler furnaces, found that the carbon, lost as fuel, never exceeds 1 per cent., while on the average it is 0·5-0·75 per cent. The average amount of soot given out by a domestic fire has been shown to be over 6 per cent.[2]

If then we take 6 per cent. as the minimum loss on the estimated yearly consumption of coal for household purposes, and 0·5 per cent. as the minimum loss on the estimated factory consumption for the United Kingdom, the loss of fuel in the form of soot will be :—

6 per cent. on 32 million tons (domestic consumption)	1,920,000
0·5 „ „ 100 „ (factory „)	500,000
tons	2·420,000

That is to say, nearly 2½ million tons of soot escape into the air annually. Of this a certain amount falls *in situ*, of which a fraction sticks by virtue of the tar which it contains. The great bulk is blown away. The portion which deposits where the fuel is burnt has been estimated by several independent observers.[3] The following figures represent the amounts of annual deposit in tons per square mile :—

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[1] "Soot: Its Character and Composition," by J. B. Cohen and A. G. Ruston; *Journ. Soc. Chem. Ind.*, *30*, 23.

[2] Cohen and Russell; *Journ. Soc. Chem. Ind.*, 1896, *15*, 86.

[3] "Soot: Its Character and Composition," Cohen and Ruston; *Journ. Soc. Chem. Ind.*, *30*, 23.

"Air Pollution in Glasgow and other Towns in Scotland," P. Fyfe, Manchester Smoke Abatement Conference, Nov., 1911.

"The Sootfall of London," *The Lancet*, Jan. 6, 1912.

	Outskirts	Town
Leeds (Cohen and Ruston)	25	539
London ("The Lancet" Laboratory)	Sutton, Surrey 58	426
Glasgow (P. Fyfe)	Total for Bo'ness 75	820

Further, it has been shown that in the three towns together, 50,000 tons of soot falls in the year, or if the same rate per head of the population is taken, it will amount, for the whole country, to half a million tons. This figure is obviously too high, as it includes a large country population, where the amount of soot per head will naturally be less. Now it has been shown that in Leeds, of the total amount of soot produced (35,000 tons), rather over one-tenth is deposited (3,520 tons). In the same ratio the amount for the whole country will be about 300,000 tons. This simply means that of the whole quantity escaping into the air (2,420,000 tons), which will in time reach the ground somewhere, only 300,000 tons falls where it is actually produced.

We have not yet referred to the most deleterious and unsightly ingredient in the soot, namely, the tar. If soot consisted merely of mineral ash and carbon, the first downpour of rain would wash it away; but the tar, which is so largely present in domestic soot, adheres like a varnish to everything, even the polished surface of glass, from which it cannot be detached by running water. The leaves of trees, and especially evergreens, become coated with this black deposit. Unfortunately, it covers the whole leaf, filling up the pores and thus checking the natural process of transpiration and assimilation. It is, in fact, no uncommon thing to find in the case of leaves of conifers grown in Leeds that 80 per cent. of the stomata are choked with tar.

The amount was estimated by exposing glass plates, one foot square, at different stations within and outside the town for three months. The surface was then washed with running water to remove loose material, and the deposit removed and analysed. The following results were obtained: stations 1, 2 and 3 are in the industrial and town area; stations 4 and 5 are residential centres, and station 6 is on the outskirts :—

	Deposit of tar per sq. ft. in m'grms. March—May 1910.	Deposit of tar per sq. ft. in m'grams. June—Aug. 1910.	Deposit of tar per annum in cwts. per sq. mile.
1. Hunslet	52·6	46·5	110
2. Kirkstall	26·2	31·1	64
3. Philosophical Hall ...	26·4	30·4	68
4. Headingley	11·3	17·2	27
5. Observatory	15·4	9·0	32
6. Roundhay	2·0	2·1	4·5

Although the quantity of tar deposit represents only a small portion of the total deposit, it must be remembered that it is cumulative in its effect and when once deposited it remains. There are two ingredients in soot which are often overlooked, namely, sulphuric acid and arsenic. Both these substances are usually present, and both have their specific action. The former is highly corrosive, and will attack the material-fabrics, masonry or vegetation upon which it falls. The arsenic in soot is derived from the arsenical pyrites of the coal. That nearly all kinds of coal contain arsenic has long been known.[4] The same is true of soot, the quantity varying with the distance from the grate. The following analyses were made of domestic soot removed at different points in the flue :—

	Distance from the fire-place.					
	10 ft.	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.
Arsenic per cent	0·0016	0·0033	0·0042	0·0068	0·0040	0·0013

The quantity increases to a maximum at 25 feet and then diminishes. The result is what might be anticipated; for both arsenic and its oxides are readily volatilised and would deposit at the cooler part of the flue, from which point the quantity would again decrease. As arsenic is always present in soot, it is not surprising to find it in town dust, so that it may be stated as a general truth that in towns where there is dust there is arsenic. Mr. Delépine, in his evidence before the Royal Commission on Arsenical Poisoning, gave it as his opinion, from observations on the lungs of colliers and those residing in towns, that "soot from towns where arsenical coal is used is far more irritating to the lungs than pure coal dust."

There are many other interesting facts connected with soot which might be discussed, such, for example, as the loss of daylight produced by the smoke cloud hanging over industrial centres, and its effect on vegetation, also the enormous cost entailed in washing.

One thing is certain, that the financial loss derived from the loss of fuel is a small fraction of the actual monetary loss to the nation.

The Institute of Metals' Corrosion Research.—The corrosion investigation recently taken up by the Institute of Metals, is now being actively pushed forward. The experimental condensing plant has been working continuously at Liverpool since 1st January, and valuable data are being accumulated. Indispensable though such first-hand information may be, the Corrosion Committee recognise the desirability of learning fully as to the experiences of others on the subject of the corrosion of brass condenser tubes. To enable information on this subject to be readily obtained, the Committee have had prepared a Corrosion Enquiry Form, and it is desired that a copy of this form should be in the hands of every person interested in corrosion, and that the 24 questions contained in the document should be answered as fully as possible, the document when completed, together, if possible, with a sample of a corroded tube, to be sent to the Institute of Metals at Caxton House, Westminster, S.W

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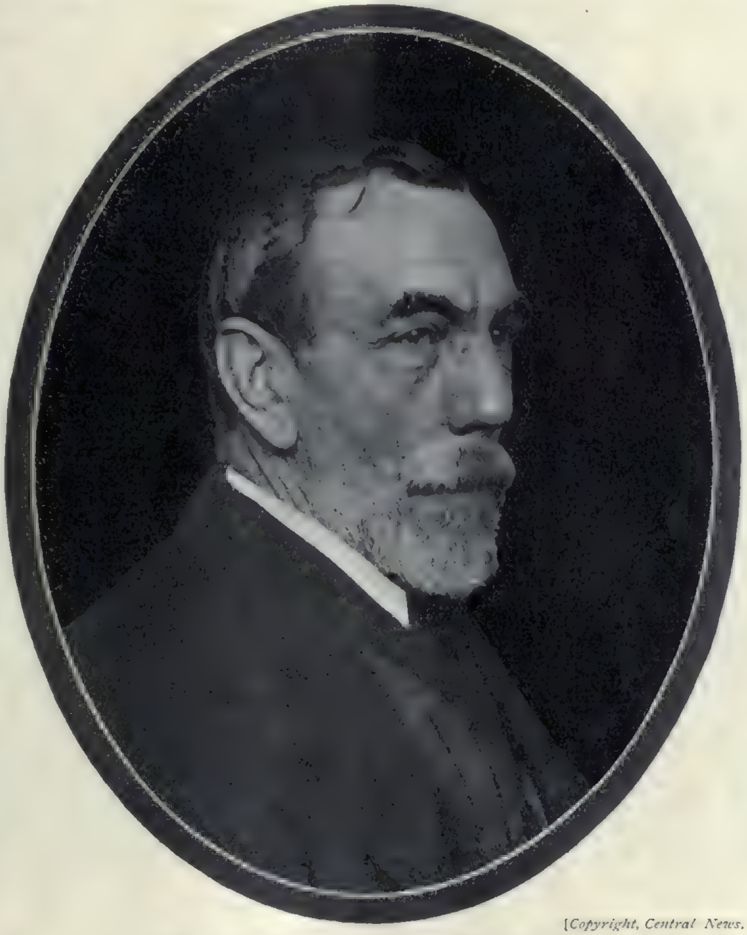
[4] Report of the Royal Commission on Arsenical Poisoning Part I., 1901; Part II., 1902-3.

SIR WILLIAM RAMSAY, K.C.B., F.R.S., F.I.C.

By A. W. Stewart, D.Sc., Lecturer on Organic Chemistry in the Queen's University of Belfast.

When we look back over the last decade in chemistry, two names stand out very clearly, those of van't Hoff and Ramsay. Last year the subject suffered a grave loss in the death of the former, then just on the threshold of a new research which promised to yield results equalling in their breadth and importance those obtained by him in other fields. This year, Ramsay, with the new laboratories at University College at last fairly on their way to materialisation, has resigned his professorship and retires from academic life. Though this does not mark the end of a scientific career, yet in a minor degree it means the loss of a great asset: for one of the most stimulating personalities among modern chemists is now withdrawn from direct contact with the younger generation which is growing up in our laboratories.

Born in Glasgow in 1852, Ramsay began his scientific career as a student in the University there, working under the late Lord Kelvin, as well as in the Chemical Department. Later, he continued his studies in Germany under Fittig, and thereafter returned to Glasgow as an assistant. In 1880 he was appointed to the Professorship of Chemistry in University College, Bristol, becoming Principal of that institution in the following year. Six years after this, he was selected as the successor of Williamson in the Chair of Chemistry at University College, London, from which he now retires, after a service of a quarter of a century.



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Sir W. Ramsay, K.C.B., F.R.S., F.I.C.

Although it is true that during Ramsay's student days in Germany the weapons with which Kekulé and Couper had armed the scientific chemist were beginning to lose their novelty, yet the enthusiasm for the organic side of the subject still continued strong, and one is not surprised to find that Ramsay, like many others, began his researches by the investigation of organic compounds. His dissertation for the degree of Doctor of Philosophy took the form of a study of the toluic acids. His interest in this branch of the science, however, was evidently not strong, for the record closes in 1879 with a couple of papers on quinine published in conjunction with Dobbie.

In this same year, the first paper of Ramsay's upon what, later, came to be known as physical chemistry, was published; and in it, even at this early date, we find traces of the faculty which has distinguished him throughout his career: the capacity for devising the most simple and direct method of obtaining a given result. The paper deals with the determination of the molecular volumes of substances at their boiling points, and the methods employed previously had been cumbersome. Ramsay reduced the apparatus to the utmost simplicity. A vessel with a small orifice was filled with the given liquid and suspended in an outer jacket containing more of the liquid. The liquid in the jacket was then boiled, and its vapour heated the liquid in the inner vessel, practically to boiling-point. In consequence of expansion, liquid was forced out of the inner vessel until equilibrium was finally obtained at the boiling-point temperature. All that remained to be done was the weighing of the liquid left in the inner vessel after it had cooled: knowing this and also the capacity of the vessel, the volume of a given weight of liquid at its boiling-point could be calculated.

In the early eighties the trend of Ramsay's work towards physical chemistry became more strongly marked: he then published the first of a long series of connected investigations upon vapour pressures, most of which he carried out in conjunction with Young; and a further field was opened up by Ramsay and Shields in their researches upon the molecular complexity of liquids. From an examination of the molecular surface energy of various substances it was shown that liquids may be divided into two classes, the members of one class being composed of simple molecules, while those of the other class contain groups of molecules associated together in complexes. Water and the alcohols form the best examples of the latter class.

We now come to the year 1894, which must rank as one of the most interesting in the history of inorganic chemistry. A quarter of a century before, Mendeléef had laid down the periodic classification of the elements according to their properties and atomic weights, and in the interval numerous elementary bodies had been discovered which fitted quite naturally into the classification. With startling suddenness, half a decade saw the discovery of five new elements, none of which could have been predicted from the original table, and the existence of which necessitated the addition of a whole column to the classification. Nor was this all, for the properties of these new elements were such as to differentiate them sharply from any elements with which we had hitherto been acquainted.

At this time Lord Rayleigh was engaged upon an investigation of the densities of various gases; and on comparing the density of atmospheric nitrogen with that of the same gas obtained from purely chemical sources, he found that there was a considerable difference between them. He explained this result by the assumption that nitrogen was capable of existing in two allotropic forms, as we find to be the case with other elements such as sulphur and phosphorus. Ramsay suggested, as an alternative, that possibly Rayleigh's atmospheric nitrogen contained an admixture of some other gas of greater density than pure nitrogen. A joint investigation followed. Rayleigh, using a method originally devised by Cavendish, removed nitrogen from a sample of "atmospheric nitrogen" by sparking it in presence of oxygen and absorbing the nitrogen oxides by means of caustic potash, while Ramsay converted the nitrogen into nitride by passing the gas repeatedly over heated magnesium. The results in both cases were similar: at the end of the process in each case there remained a volume of gas which certainly was not nitrogen.

An examination of the specific heats of the gas at constant pressure and constant volume showed that it was monatomic and therefore an element. Further investigation proved that it was apparently absolutely inert and did not enter into combination with any other element. On this account it was named argon (*i.e.*, ἀργόν) = ἀεργόν, from ἀ—*privative*; and ἔργον—*work*.

The next problem which faced its discoverers was to assign a place to the new element in the periodic classification; and it became clear that in order to do this, a special column would have to be inserted in the table. Up to that time the third series in the periodic system had begun with the strongly electro-positive element sodium, and continued through a range of elements gradually ceasing to be electro-positive and becoming electronegative, until it ended with the strongly electronegative substance chlorine. The next element in the series is potassium, which is similar to sodium; so that there was an abrupt transition from the strongly negative to the strongly positive body. It was finally agreed that, instead of this abrupt change, the element argon should take its place between chlorine and potassium, so that the series at this point ran as follows:—Chlorine (negative), argon (inert) and potassium (positive). Thus argon formed the transitional element between the two extremes, and a new column was added to the table to contain it.

About this time Hillebrand had observed that some uranium ores when boiled with acid gave off a gas which he imagined to be nitrogen. Ramsay, being now anxious to examine any specimens of nitrogen from natural sources, procured some of the mineral in question—cleveite—and examined the gas obtained from it. On comparing the spectrum of the cleveite gas with that of argon, he found that the new gas gave a brilliant yellow line, which at first he attributed to the presence of sodium, but more careful examination of the spectrum showed that the line in the gas spectrum did not exactly coincide with the D-line of sodium. Finally the new line was found to be characteristic of a substance, helium, which in 1868 had been detected spectroscopically by Lockyer among the constituents of the solar atmosphere, though helium itself had never been obtained from terrestrial sources until it was isolated by Ramsay.

The properties of helium were then examined, and it was found that, like argon, it was chemically inert, and that, next to hydrogen, it was the lightest of the elements. When it was placed in its appropriate position in the periodic table it became clear that there was a possibility of a third element existing, whose position in the table lay between helium and argon.

In conjunction with Travers, Ramsay began a search for this as yet undiscovered body. They examined various meteorites, several mineral waters, and about a hundred and fifty minerals, but without success, and it became clear that if any further inert gases were to be found they must be sought for in the air. Fortunately, at this period liquid air could be obtained in fairly large quantities, and by a careful fractionation of this the two investigators discovered three more elements, which were characterised by means of the spectroscope. To these the names neon, krypton and xenon were given. Further investigation necessitated the use of liquid hydrogen, which at that time was not obtainable at University College; and a special apparatus was designed and built by Travers in the laboratories in order to produce enough for the purpose. When this was ready, its use resulted in the separation of the incondensable helium from the solidified neon. Thus in 1901 Ramsay and Travers were able to publish their paper on "Argon and its Companions," in which no less than five new elements were described. This closed a chapter in the history of inorganic chemistry which, so far as we can see at present, is likely to remain unparalleled.

Sir W. Ramsay Lecturing at University College, London. [Copyright, Central News.

Curiously enough, while Rayleigh and Ramsay were beginning their work on argon, another investigator in a different field was preparing the ground for even more striking researches, in the history of which Ramsay has played a leading part. In 1895 Röntgen discovered the X-rays; and, a year later, Becquerel proved that certain salts emitted rays having properties similar to those of Röntgen rays. These investigations culminated in the discovery of the radioactive elements.

The subject is still so fresh in the minds of the chemical public that it is unnecessary to go into details here, and we shall confine ourselves to that section of the subject with which Ramsay was directly concerned. It will be remembered that radium and the other radioactive elements give off very small quantities of emanations which possess radioactive properties. In conjunction with Soddy, Ramsay began the study of the emanation given off by radium (a gas now called niton), which apparently belongs to the class of inert gases like argon. The mere experimental difficulties of this type of work may be gauged from the fact that the amount of emanation from one gramme of metallic radium in radioactive equilibrium is much less than a cubic millimetre, while the weight of radium salt (which of course is not all radium) employed in the investigation was sometimes as small as 0·02 gramme. From this it is evident that only the most refined manipulation could cope with such a research.

Ramsay and Soddy showed that if a tube be filled with emanation, the spectrum of the gas is at first that of niton, but that after some days the spectrum of niton is gradually displaced by that of helium. Thus it became clear that niton, which has all the properties of an element of the argon group, gradually and spontaneously yields helium. In the light of this discovery, as well as that of the conversion of radium into niton, a controversy arose with regard to the proper definition of an element, for apparently, under the old definition, neither niton nor radium itself could be classed as an elementary body.

Ramsay next, in conjunction with Gray, began an even more difficult piece of work: the determination of the critical constants of niton. Bearing in mind the very small quantity of gas with which they had to deal, the successful conclusion of the work appeared at the time to be the last word in manipulative exactness. Niton was condensed to a clear colourless liquid, glowing with a peculiar phosphorescence.

This investigation, however, was soon surpassed in refinement by the next work undertaken by Ramsay and Gray: the determination of the atomic weight of niton by direct weighing of the gas. When we recall that one cubic millimetre of niton weighs less than a thousandth of a milligramme, and that an accuracy of 1 per cent. was aimed at, it is evident that it was necessary to construct a balance which would turn with a load of one-hundred thousandth of a milligramme (0·00000001 gramme). This result was actually obtained in practice by employing a variation in pressure within the balance case instead of weights, and the result represents probably the high-water mark of fine apparatus.

Looking back over Ramsay's career, it is evident that his greatest successes have been attained in fields in which the study of gases and their properties are predominant, and it is interesting to note that in this branch of the subject British chemistry has played a chief part. In this country the greatest names in chemistry have in one way or another been associated with this line of development. Boyle, Black, Cavendish, Priestley, Graham and Andrews, all owe their fame to their work in this branch, and in Ramsay we have the youngest representative of this great school of investigators.

An account of Ramsay's career would be incomplete without some reference to his relations with his students. The director of a great laboratory, whose time is occupied with administrative details and with questions of general policy as well as with his own researches, might well be excused from taking a close interest in the work of students whose investigations lie in fields somewhat remote from those in which he himself is more immediately engaged; but no such excuse was ever necessary in the University College laboratories. Ramsay has always remained in close touch with his men, and a visit from the Chief to a student's bench almost inevitably meant that some fresh aspect of the subject under investigation would be brought to light in the course of a brief discussion. From the students' point of view these visits were valued, not only for the manner in which he was able to convert what had previously been merely a nebulous idea into a practical problem, but also for the stimulus of his kindly encouragement. Those who were in difficulties could always rely upon his ungrudging aid, which was given on all occasions to those who sought it.

NOTES OF MEETINGS, &c.

EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

WASHINGTON AND NEW YORK.—*September*, 1912.

INSTRUCTIONS have been issued as to the presentation of Papers. These with other contributions should be *original and not elsewhere read or published*: however, prior publication of Governmental researches, which publication is made in accordance with the law of such country, shall be exempt from the above restrictions as to publication.

No Paper offered to and accepted by this Congress can be at any time published elsewhere without credit to this Congress for such article or publication.

The Congress reserves the right to reject any Paper or other contribution that may be offered to it.

Papers and their abstracts, *both in duplicate,* must be in the hands of the American Committee not later than June 30th, 1912.

The Congress reserves the right to print the full Paper only, or the abstract.

THE INSTITUTE OF METALS.

The third May Lecture will be delivered on the 10th May, by Sir J. A. Ewing, K.C.B., F.R.S., on the subject of "Inner Structure of Simple Metals."

The Annual Autumn Meeting of the Institute of Metals will take place in London, the Meeting being held on two days in the last week of September.

THE CHEMICAL SOCIETY.

April 18th.—Ordinary Meeting, 8.30 o'clock.

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SOCIETY OF PUBLIC ANALYSTS.

April 3rd.—Ordinary Meeting, 8 o'clock.

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SOCIETY OF CHEMICAL INDUSTRY.

LONDON SECTION: April 1st.—8 o'clock.

Annual Election of Members of Committee.

The following Papers will be read and discussed:—"The Theory of Sulphuric Acid Manufacture," by W. C. Reynolds and W. H. Taylor; "The Estimation of Sulphides in Lime Liquors," by J. R. Blockley and P. B. Mehd.

* * *

ROYAL INSTITUTION OF GREAT BRITAIN.

April 1st.—General Meeting.

The following are among the Lecture Arrangements after Easter:—Prof. A. W. Crossley, two lectures on "Synthetic Ammonia and Nitric Acid from the Atmosphere." The Friday Evening Meetings will be resumed on April 19th, when Mr. Alan A. Campbell-Swinton will lecture on "Electricity Supply: Past, Present and Future." Succeeding Discourses will be given by Sir George H. Darwin, W. C. Dampier Whetham, Professor W. Stirling, W. Duddell, Professor Howard, T. Barnes, Sir William Macewan, and others.

Present Position of Electro-Analysis.

By Henry J. S. Sand, Ph.D., D.Sc.

(*Continued from page* 53.)

The cathode is rotated in the apparatus described by Gooch and Medway, and by F. Mollwo Perkin. The former employ a platinum crucible, the latter an electrode constructed of wire gauze.

The last-named form has been adopted particularly by T. Slater Price and his co-workers in their studies on electro-analysis (Price and Judge, *Trans. Faraday Soc.*, 1906, *2*, 85). To hold the electrolyte they employ a separating funnel. This device, which has been fairly widely adopted, is designed to facilitate easy washing of the precipitated metal. Quite recently Price and Hyde (*Journ. Soc. Chem. Ind.*, 1911, *30*, 391) have introduced a modification in the form of a two-way tap. The adoption of auxiliary apparatus of this kind will depend largely on the electrodes employed.

Thus, with the electrodes used by Sand, washing is effected in a perfectly satisfactory manner without the use of any auxiliary apparatus in an ordinary beaker, and with very much less wash-water than is required in the separating funnel. Two stationary concentric gauze electrodes, used in conjunction with a glass stirrer, have been described by Arthur Fischer (*Zeit. Elektrochem.*, 1907, *13*, 469), and may be employed for separations by graded potential. We now come to the methods in which vigorous stirring is effected without the use of mechanical appliances. These are, stirring by electro-magnetic means, stirring by the gases evolved during electrolysis, stirring by means of hydrogen, and stirring by means of enlarged bubbles of gas produced under reduced pressure. It is somewhat doubtful whether the same efficiency of circulation can be obtained by any of these means as by mechanical stirring, and the first two methods suffer in addition, from the fact that the rate of stirring depends on the current which is employed for the analysis, increasing and decreasing with it. In most cases, however, there is a considerable simplification of apparatus. The electromagnetic method was introduced by Frary (*Zeit. Elektrochem.*, 1907, *13*, 308), and consists in surrounding the beaker by a solenoid, which produces a vertical magnetic field in the solution contained in the latter; the electrodes are arranged so that the lines of flow of the current radiate from the central axis of the beaker to its circumference. Rapid revolution of the solution is thus produced. J. T. Stoddard (*Trans. Amer. Chem. Soc.*, *31*, 385) has found that a considerable number of metals may be deposited from solution with high current-densities without any further stirring than is produced by the gas-bubbles and the heating effect of the current. They employ cathodes of platinum gauze and of mercury. According to Price and Humphreys (*Journ. Soc., Chem. Ind.*, 1910, *29*, 307), however, the method is neither so rapid nor so accurate as that with artificial stirring, besides it is manifest that it is only suitable for small quantities of electrolyte. During the past year, however, the method has again been advocated by several workers in the laboratory of the Tucson University of Arizona (R. C. Benner and M. L. Hartmann, *Journ. Amer. Chem. Soc.*, *32*, 1628—36, and R. C. Benner and W. H. Ross, *ibid.*, *33*, 1106—12). Quite recently they succeeded in depositing about 0·15 gram of copper and nickel in about 10 minutes from about 150 cc. of solution while stirring the latter with hydrogen (*Zeit. Elektrochem.*, 1911, *17*, 905). The electrolyte is contained in a large boiling-tube, loosely closed at the top by a funnel without a stem. The tube for introducing the hydrogen passes through this, a wire forming the anode is wound around it, and the hydrogen enters the liquid through a large number of small holes. The cathode is a cylinder of platinum gauze. The apparatus is designed so as to make loss by spitting impossible. The same authors also describe a similar piece of apparatus for working under reduced pressure, the temperature of the electrolyte being kept at about 70° Under these conditions the gas-bubbles produced by electrolysis, mixed with water-vapour, are much larger than they would be under atmospheric pressure, and thus have a greatly enhanced stirring efficiency. In all the apparatus considered so far, the cathode is made of platinum. Other metals may, however, be employed, if only they are more noble than the metal to be deposited. The application of mercury has undoubtedly led to the most striking results in the hands of various investigators working in the laboratory of Edgar F. Smith (*Journ. Amer. Chem. Soc.*, *26*, 1614; *ibid.*, *27*, 1527; Myles, *ibid.*, *26*, 1124; Hildebrand, *ibid.*, *29*, 447; Goldbaum and Smith, *ibid.*, *30*, 1705, and *32*, 1468 (1910). Not only may metals, such as zinc, be deposited into the mercury from solutions of the sulphate, and the remaining acid be titrated, but even the alkali metals and alkaline earth metals have been determined and separated from each other from solutions of their chlorides, bromides, etc. To do this, a cell resembling the Castner-Kellner cell for the manufacture of caustic soda is employed. The halogens are deposited on a rotating anode of silver gauze, while the alkali metal is dissolved by the mercury and afterwards produces hydroxide as the anode in a salt solution. The alkali produced is then determined by titration.

When cathodes of metals other than mercury and platinum are employed, reduction of cost is usually the object. Nickel silver, copper, brass, gold, platinised nickel, and also graphite (Turrentine, *Zeit. Elektrochem.*, 1910, p. 568) have been proposed. Sand and Smalley (*Trans. Faraday Soc.*, Dec., 1910, and *Chem. News*, 1911, *103*, 14) have recently published determinations of copper carried out by means of a silver cathode. The deposit was removed after electrolysis by the use of a hot solution of sulphuric acid, containing some hydrogen peroxide. The apparatus was designed to approximate to Sand's platinum electrodes, but the anode was made mainly of glass, a reduction of the weight in platinum to about 5 grams being thus secured. Determinations of zinc on a nickel cathode were also made with this apparatus.

The separation of metals from each other by electrolysis is a matter which has always attracted a large amount of attention from analysts, and separations were carried out almost as early as the first determinations. The importance of the voltage between the anode and cathode was first pointed out by Kiliani in 1883, and Leblanc in 1891 (*Zeit. Phys. Chem.*, *8*, 299), established the scientific basis of electrolytic metal-separation, by showing that every metal has a decomposition-pressure peculiar to it. The more recent work by Foerster and his co-workers, and by Sand and Black, also bears on this matter. Freudenberg (*Zeit. Phys. Chem.*, 1893, *12*, 97) was the first to apply Leblanc's theory systematically, and carefully regulated the voltage between the electrodes. A paper bearing on this method of metal separation has been published during the past year by O. Brunck (*Zeit. Angew. Chem.*, *24*, 1993—1997), who recommends the use of the Edison-Accumulator on account of its low voltage. In the majority of the commoner electrolytic separations constant currents are employed, and the solutions are chosen so that only the more noble metal is deposited, after which hydrogen makes its appearance, the less noble metal remaining in solution.

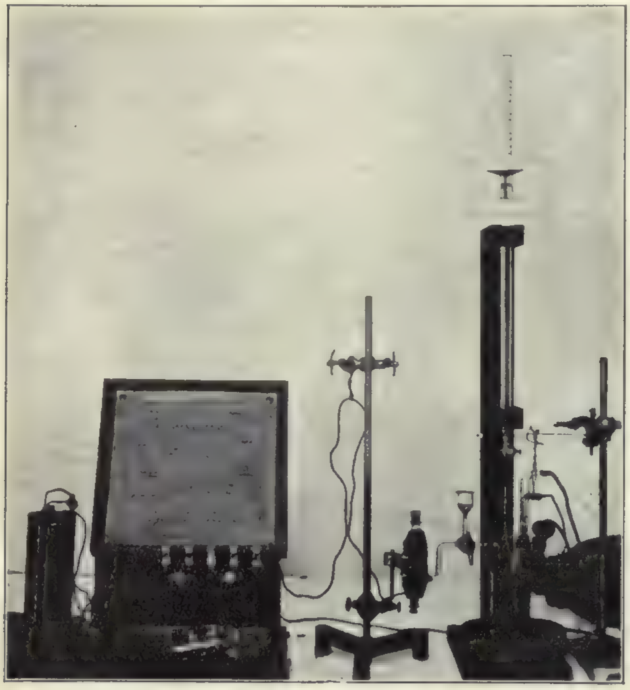


FIG. 1.

The voltage at which hydrogen is generated on the surface of an electrode is determined largely by the so-called supertension or over-voltage of that metal, and this circumstance is one of great importance in electro-analysis. In connection herewith reference must be made to the numerous determinations and separations due to Hollard and Bertiaux (*Analyse par Electrolyse*, Paris, 1906) in which due consideration has been given to these factors.

Most electrolytic methods of metal-separation may be transferred unchanged from stationary to rotating electrodes. A very great extension of these methods is, however, attained in the case of the rotating anode, when an auxiliary electrode is employed. This device was introduced into electro-analysis by Sand (*Trans. Chem. Soc.*, 1907, *91*, 373). By its means the potential of the cathode may be accurately adjusted, and as a result, it is frequently possible to confine the electrolytic action of the current entirely to the deposition of one metal. In consequence of this the current sinks to almost zero when the metal to be determined has been removed, and the analyst knows when to stop the determination. Many separations, such as that of bismuth from lead and antimony from tin in acid solution, may be carried out by Sand's method of graded potential, but would not be possible by any other. In many cases, too, metals may be readily obtained in a coherent form from solutions which would otherwise yield spongy deposits. The reason of this is, that spongy deposits are undoubtedly frequently due to the intermediate production of metal hydrides, and the method of graded potential enables the analyst to treat the deposition of the metal as a separation of it from hydrogen. The electrical apparatus for these separations has been combined in a portable form by Sand in one potentiometer-box, which also takes the part of the voltmeter in ordinary analysis (*Trans. Faraday Soc.*, 1909, p. 159). This box, the auxiliary electrode, and a dry cell, are the only additional pieces of apparatus which the method requires. A potentiometer-box, serving a similar though not quite so general a purpose, has also been described by Arthur Fischer (*Chemiker Zeitung*, 1909, p. 337).

A very brief reference must now be made to various directions in which electro-analysis appears to be developing at the present time. It is well known that electrolytic methods have occasionally served for atomic weight determinations, as in the case of Classen's atomic-weight determination of tin. In the past year several papers dealing with this subject have appeared. W. H. Perdue and G. A. Hulett (*Journ. Phys. Chem.*, 1911, *15*, 147—154) recommend the use of mercury cathodes for this purpose, and state various precautions which must be observed when results of the highest accuracy are required. Jacob S. Goldbaum (*Journ. Amer. Chem. Soc.*, 1911, *33*, 35—50) has determined the ratio of the atomic weights of sodium, chlorine and bromine with very good results. The author states that his object was rather to obtain a check on the accuracy of the electrolytic method referred to above than to improve the known values of atomic weights.

Of other directions in which electro-analysis is capable of expanding, that of micro-chemical analysis should be mentioned. Several fairly successful attempts in this direction have been made at various times, but no further advance is to be recorded for the past year (Jänecke, *Zeit. Anal. Chem.*, 1904, *43*, 547; Brill and Evans, *Trans. Chem. Soc.*, 1908, *93*, 1442; Emich and Donau, *Sitzungsberichte. K. Akad. d. Wiss. Wien*, 1909, *118*, 6).

Two applications of electrolytic methods to analysis must, in conclusion, be referred to. The first is the conductivity method. It is said frequently to supplement or take the place of density determinations by the hydrometer in sulphuric acid works and other chemical manufactories. It is also said to be employed in testing waters for boiler purposes.

The last application in which substantial advances have been made is the determination of hydrion-concentration, by measuring the potential of the hydrogen electrode. Owing to the improvement in rapid methods of measuring potential and in the form of auxiliary electrodes (Sand, *Trans. Faraday Soc.*, 1909, *5*, 159), such determinations have become much more rapid and easy to make than formerly. In numerous industries, such as leather manufacture, the hydrion-concentration of the liquors is undoubtedly of great importance. Such liquors are also frequently very difficult to titrate for free acid or alkali, owing to their dark colour and the insensitiveness of indicators to the weak acids or alkalis present. In all such cases the determination of the end-point of the titration by the electrometric method offers great advantages. Two papers dealing with the application of this method to the titration of tan-liquors have been published by Sand and Law, and Wood, Sand and Law respectively (*Journ. Soc. Chem. Ind.*, 1911, *30*, pp. 3 and 872). The illustration shows all the apparatus required for a titration set up for use.

NOTES ON CHEMICAL RESEARCH.

By The Editor.

CHAPTER III.

General Procedure and Selection of Methods of Investigation.

> "No scientific discovery can with any justice be considered as due to accident."—*Gore.*

Scheme of Procedure.—It is necessary to consider this in detail before actually starting work. As the course of the investigation develops, or takes a new direction, original methods and plans may be modified or altered, or, in extreme cases, rejected in favour of others. Where the investigation is of a definite nature such further treatment may be unnecessary; but this must not be looked for in cases where a research involves complicated conditions. Thus the investigator always has before him the question of possible improvements in manipulation, or alternate methods of working, and the influence these may have on the work in hand. Even in the case of the isolation of an alkaloid, or the preparation of a definite substance, the possibility of improvement in method should be constantly in mind.

When a point in theory is under consideration; or an investigation undertaken, entailing a series of changes, or measurements, which cannot be at the time explained or fully understood; or when changes in molecular constitution or complex laws have to be followed up, or investigated, subsequent alterations in procedure will almost always be found necessary.

In industrial research the conditions are hardly less involved, for in that case phenomena which are indefinite in their nature are constantly met with. These have to be constantly investigated, or at least controlled, before any real progress on the line originally determined upon is at all possible.

Thus working conditions have often to be varied during the progress of an investigation, even when its ultimate object is fully disclosed from the commencement. Where this takes the direction of a search for new methods, or conditions, for arriving at a definite position, the research may chiefly consist in the determination of the best conditions to that end. That student may well put on one side such work for his more experienced years. In more or less simple research the beginner may often find himself face to face with conditions which seem to indicate the complete failure of his investigation. Sooner or later some way of dealing with such a position will probably be discovered, or a new method of attack may be devised. He should do all he can to hasten this result, and bring it within his experience.

In dealing with such a position, past experience is the most valuable asset in determining the probable line of least resistance, and progress. No advantage can be gained by the beginner rushing into an elaborate research. Such work should be confined to problems which entail easy methods of procedure. This point must always receive full consideration when the nature of the investigation is being determined in the first instance.

Chemical research may roughly be stated as belonging to two different types:—

(1) When known or general reactions are employed.

(2) When inventive power must be brought into play, and new methods, or conditions of working, devised.

Examples of the first class should first engage the attention of the investigator. Their value, from a point of view of ultimate training and experience, may possibly be inferior in many ways, but from their nature they may be undertaken with more certainty by the beginner. They are better suited to his immediate requirements.

In organic chemistry the production of new compounds by known methods may be the chief aim in the investigation, although an examination of the conditions under which the reactions proceed may be of equal importance. Research in this direction is sometimes hastened by its connection with commercial aims, as in the aniline dye industry. In organic research dealing with theory, the production of new compounds by familiar reactions may represent the practical side of the investigation. General reactions in this branch of chemistry are sometimes of great value, and the discovery of a new one may at any time have far-reaching results on the general progress of organic research.

This branch of chemistry has in the past been in general favour for research purposes. It is easily undertaken in the college laboratory. It is also a convenient introduction to more general investigation, or a suitable subject for continued work. When estimating its value in the former case it will be remembered that many experienced investigators, now working in other directions, obtained their early training in this branch of research.

The nature of research undertaken during the general period of training may be governed by certain considerations of a more or less personal nature. Subject to certain necessary restrictions, these may receive consideration when choosing a subject for investigation. The ultimate aim should be one of general utility, and the research should involve an advance in actual training and experience.

Methods of Carrying out Research.—Following the selection of subject matter on such grounds as are indicated, the actual methods of investigation adopted represent the next point for consideration. These are determined and governed by the nature of the special conditions which have to be met. When new methods have to be devised, apparatus designed, or even invented, this preliminary step may in some cases be regarded as the chief feature of the research. The subsequent recording of results by its use may be considered as playing a secondary part.

It must always be remembered that when the ordinary apparatus of a well-fitted laboratory is sufficient, the use of specially-devised and constructed apparatus is undesirable. In organic research working conditions may generally be met in the ordinary laboratory. In working out new methods of analysis the same conditions may be looked for. When special conditions have to be met, necessitating more complicated methods of procedure, success will depend upon the necessary conditions being determined with as little delay as possible.

In advanced research, which in some branch or other should be the ultimate aim of all investigators, special apparatus is often necessary. For example, the successful termination of a research which entails a study of reactions occurring at a very high temperature, may depend upon the experimental conditions being met in a satisfactory manner. Special methods must then be employed in the registration of the physical conditions present at the time of the investigation.

Without the electrical furnace Moissan could not have undertaken his important work on high temperature reactions. Without the vacuum-lined vessel many experiments at low temperatures would have been impossible, or only carried out with extreme difficulty. In some cases a piece of apparatus, or instrument of precision, may be the determining factor in the investigation.

Research may therefore involve the use of :—

(1) The ordinary apparatus of the laboratory.
(2) Special, but already described apparatus obtainable in commerce.
(3) Apparatus which must be specially devised, or invented by the investigator.

Extended study and practical experience are necessary qualifications when working under the last conditions. For this reason the student will do well to follow intelligently the published records of such work, and follow it with as much care and detail as if he were engaged in the work himself. An opportunity of watching an investigation in actual progress should be always taken advantage of for the same reason.

Referring to the first two cases, consideration must be given to the selection of the most suitable apparatus available; and in the order of their classification the aim should be to work under the easiest conditions. This will at the same time tend to reduce the experimental error to a minimum.

When the conditions under which an experienced investigator works are examined in detail, it will be found that in the majority of cases they conform to this rule. The simplest apparatus which will meet the necessary requirements is used. Even when new apparatus is devised it is often characterised by its simplicity.

Speaking generally, an attempt should be made to start research, or work under research conditions, before leaving college, while a knowledge of theory is still well in hand. If this is not possible, the student should leave with a determination to ultimately engage in such work, but in this case valuable time may be lost when the necessary experience has to be gained in after life. Thus a knowledge of actual working conditions rightly belongs to the college stage. Familiarity with the general conditions which surround such investigation and belong to it is a certain aid to further success. A state of mind is engendered in this way which persists through subsequent work, and is essential to success.

Another factor which operates in the same direction is present in many cases. An enthusiasm has been developed in many institutions by certain teachers who have inspired their students with similar ideals, indicating by actual example the need for the inclusion of such work in the training of students, who must in their turn engage in such investigation in the ordinary course of life. By imparting their special methods of working, they have generally given to a direction the work of others. This influence has been a determining one in the past. Examples will occur to all. The formation of so-called "schools" is the outward expression of such influence. These have always been founded on a basis of original investigation.

Another influence is frequently present, but is not so generally understood, or discussed. In many ways it is hardly less far-reaching in its effect, but it is of an impersonal nature. It is felt by those who are in constant contact with operations proceeding on an industrial scale, with continuous regularity over long periods.

Its influence on the investigator is difficult to define, but those who have grasped its meaning are known as having a practical turn of mind. They possess a power of intuition and initiation in industrial research which is not often met with in those who have not passed through this experience.

This training confers the quality of caution, combined with an instinct for working in practical directions. Such an experience frequently enables a man to outclass one with a superior theoretical knowledge. It brings with it confidence, and some additional qualifications which favourably influence the conduct of original work.

(*To be continued.*)

CHEMICAL ENGINEERING.

NOTES ON THE SUGAR-BEET INDUSTRY.

By R. N. DOWLING (Agricultural Adviser to The National Sugar-Beet Association, London).

(Continued from page 102.)

THE average yield of above crops as stated by the Board of Agriculture and the German authorities are :—

SUGAR-BEET.	MANGOLDS.	SWEDES and TURNIPS.
Germany, 12 Tons.	England, 20 Tons.	England, 14 Tons.

VACUUM PLANT.

My valuation of 7*s.* 6*d.* per ton for mangolds is based on two years' trials carried out with fatting beasts at Wye College on roots *v.* a sugar food. The sugar food cost £5 per ton, and 1 lb. gave the same results as 14 lbs. mangolds, both as to weight and cash returns.

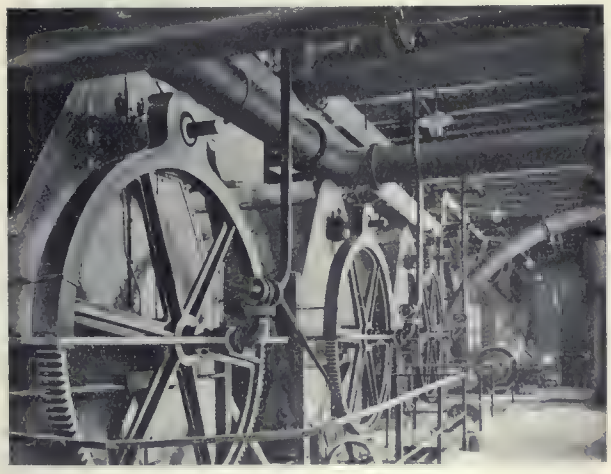
I am quite aware that these figures can be altered according to the district, and therefore they must be *read in an explanatory sense and not as a hard and fast rule.* I have ignored residual manurial value, as such would be very much alike in both cases.

The mangolds or swedes would be fed on the farm direct, and the pulp or beet slices would and must be returned from the factory.

This is the practice in every country that I have visited, and I never once met an exception to this rule. Some factories pay a certain price for beets and give the pulp back, others pay a higher price and charge a nominal sum for the wet pulp, or dry pulp, as the case may be. In all cases the transaction is a fair and businesslike one to factory and farmer. The farmer must have feed for stock, and naturally stipulates such in the contract. As to the value of such pulp for feeding purposes, this has been shown conclusively in all countries but our own. To demonstrate this important point I have organised trials with fatting beasts and cows at Agricultural Colleges and at the Norfolk Agriculture Experimental Station (where twenty bullocks are being used) to test the value of dried pulp *v.* mangolds.

Will Sugar-Beet Culture help to raise the Standard of Farming in England?—To my mind this seems to be the crux of the whole question to the tenant, the landlord and the community in the neighbourhood of a factory. Such undoubtedly has been the result in the great sugar-beet areas in Germany, etc. Higher yields of other crops, more head of stock per acre, increased value of land, and the general prosperity of the whole countryside has followed in the wake of the sugar-beet.

I am constantly asked why the English farmer should not carry out this deep and thorough tillage with his present crops. My answer is that it is simply a matter of £ *s. d.* The sugar-beet farmer fully realises the value of careful cultivation, but he also knows that at the end of the season he will receive a prompt cash return. His money has been turned over quickly, and he can purchase beet pulp and other foods and go on feeding stock



DRYING APPARATUS.

in the same way as the farmer who grows ordinary roots, and consequently he will turn his money over twice. Having cash to go on with, he would not be obliged to rush his corn crops on the market, as is too often the case.

The swede and turnip grower feeding his roots to sheep or other stock will have to wait some time before he gets his money back, and then it is very problematical as to whether there will be a profit or a loss. When roots are fairly plentiful it is not difficult to buy tham at £1 per acre, providing one feeds them off on the land with a little cake.

The imported labour not only cleans the beet crop, but it works over the whole of the crops, such as hoeing wheat and other corn, potatoes, etc. Thus the natural tendency is that each department is thoroughly worked, and the whole system is raised to a higher level. Practice with science becomes an accomplished fact.

In quoting some figures given me by the Director of one of the Imperial farms in Austria, let me say that careful records have been kept of yields of crops before and since the erection of a sugar-beet factory on the estate some fifty years ago.

Since the introduction of sugar-beet one-third of the area of a 1,000 acre farm has been devoted to this crop, and thus was not available for cereals. Yet we get the most interesting report that a larger aggregate yield of straw crop and grain is now obtained than when a much larger area was devoted to these straw crops. Also, whereas 40 cows were kept, 200 are now kept on the same area.

Centrifugal Machines.

I wish to state emphatically *that these statistics do not bear exact relation to our farming*, neither do I wish to assert that we should get such extraordinary results in increase, because to a certain extent mangels have already influenced our farming in the same direction, but I think such facts do serve to illustrate my contention that, looking at the question from a national standpoint, our country and nation would very largely benefit.

Now let me very briefly summarise the position to-day and compare it with bygone times:

A few years ago the "Bounty" system and "Cartels" were in existence on the Continent.

In plain words manufacturers in Germany and elsewhere were paid a good round sum per cwt. by their Governments for every cwt. of sugar exported to England.

Beet-Root Cultivation.

Such a system produced the following results:

(1) Cheap sugar in England.
(2) The ruination of our cane-sugar industries in the West Indies.
(3) Dear sugar in Germany and "Bounty" fed countries, because they had a large import duty.
(4) It was impossible to manufacture sugar in England at a profit.

In 1902 the famous "Brussels Convention" agreed to abolish the "Bounties," but also agreed not to levy an import duty of more than 2*s* 6*d*. per cwt. over the amount of excise paid. This came into operation in 1903, and has had the following results:—

(1) The cane-sugar industry has revived by leaps and bounds.
(2) Sugar has been much cheaper on the Continent, and consumption has gone up very largely.
(3) It has opened the door for a huge "British Industry."

The import duty into this country is 1*s*. 10*d*. per cwt. for raw sugar, but a sliding scale is in use, and the duty varies a little according to purity. There is no excise duty at present.

Let us examine the following figures:—

Imports for 1904—10.

	Tons.		Value.
Foreign Refined Beet-Sugar	945,540		
Raw Beet-Sugar.........	522,260		
	1,467,764	Beet-Sugar	£16,889,954
Raw Cane-Sugar	292,393	Cane-Sugar	6,689,345
Total in Tons	1,760,157	Total value	£23,579,299

This last year, I believe, the value of imported sugar was something like £25,000,000.

Look at the average under beet in a few countries:—

	1910-11	
Germany	1,170,285	acres.
Austria	900,000	,,
Russia	1,692,665	,,
France	575.529	,,
Holland	122,563	,,

Every country in Europe except our own has either developed or is developing the sugar industry.

We consume something like 90 lbs. of sugar per head per annum, which is considerably more than on the Continent, but their consumption per head is rapidly increasing. The people have learned the value of sugar because of its cheaper price, and they do not mean to have very dear sugar again.

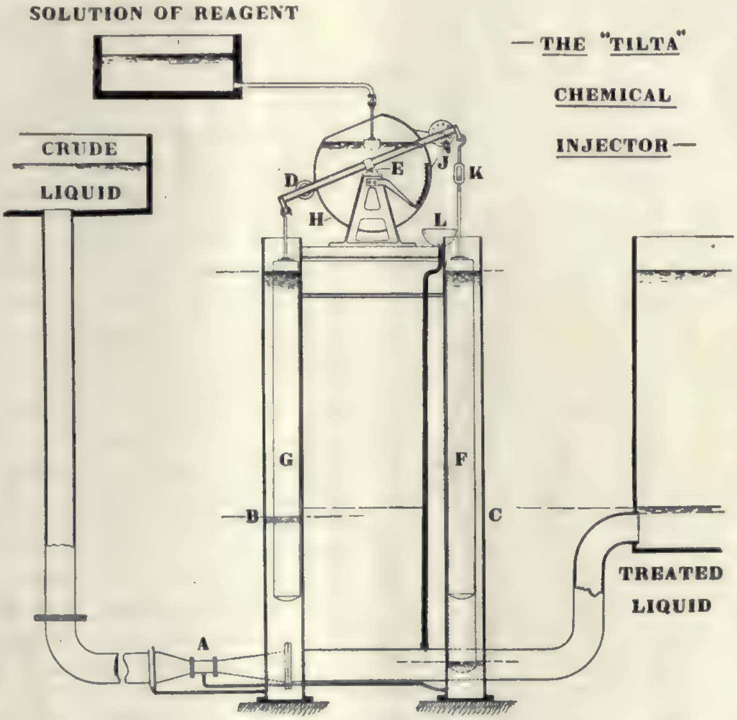
In conclusion, may I draw attention to the fact that a sugar-beet industry would not only help the landlords and farmers, but it would incidentally help engineers, and builders, and there would be enormous railway traffic? Also we might look for better cottages and roads, and a general revival of trade in country districts to supply the wants of workers.

Last, but not least, it would open out a great and practical way of helping to solve the question of the repopulation of rural areas.

A NEW CHEMICAL INJECTOR.

By J. G. DAVIS, A.C.G.I., B.Sc.Eng.

THE purpose of this new apparatus, which has been recently patented by the Hon. R. C. Parsons, M.A., M.Inst.C.E., in company with Mr. Walter Kent, director of Messrs. Geo. Kent & Co., Ltd., and provisionally named the "Tilta," is the injection of chemical reagent into a liquid which it is required to treat in a known manner, and to maintain automatically that proportion, in spite of variations in the quantity of liquor to be treated. Also by the application of an integrating apparatus the measurement of the amount of solution used and of liquid treated can be readily secured. The need for such an apparatus has long been apparent, in view of the expense attending the skilled supervision which is necessary for the attainment of the end first mentioned, and the waste arising from the employment of such reagents in excess, which follows their addition in a purely empirical manner, and is specially a source of inefficiency where the quantity of liquid requiring treatment varies from time to time, and where a legal standard of purity must at all costs be attained.



— THE "TILTA" CHEMICAL INJECTOR —

The apparatus was primarily constructed to treat large quantities of liquid by means of precipitating or softening agents, such as aluminoferric, and the like, as is necessary during the purification of sewage and of certain town water supplies; but it appears that it could be adapted to smaller scale work, such as the introduction of reagents in liquid form into the effluents from industrial establishments. In this way the problem of purifying trade wastes to the extent imposed by the local authorities might be solved in a more economical manner than at present.

The apparatus consists of two essential parts, the flow of the liquid to be treated causing the first of these to so adjust the second as to enable it to pass into the liquid the necessary proportion of a solution of the reagent. This is secured by arranging that the *rate* of addition of the reagent shall always bear the desired fixed proportion to the *rate* of flow of the liquid to be treated, so that over any interval of time the respective *quantities* bear the same ratio to one another. The accompanying diagram shows the means of effecting this. Under a slight pressure the whole of the liquid to be treated is made to pass from the upper reservoir or tank through a line of piping in which is inserted a "*Venturi*" tube (A), composed of properly proportioned taper pieces connected by a neck or constriction some half the diameter of the main portion. The velocity in the neck will be then about four times that in the full-sized portion, and to every increase in the velocity of the fluid there will correspond a loss of pressure head in the neck compared with that in the full-sized pipe. By connecting the vertical pipes B and C (see diagram) to the points of the Venturi tube where the diameter is smallest and greatest respectively, the difference of the two liquid levels in B and C will be a measure of the quantity of crude liquid passing, and may be utilized as a motive power for actuating the movable or second portion of the apparatus, by means of the *displacers* F and G. These are cylindrical bodies composed of some material heavier than water, and suspended from the ends of a lever (D), balanced on a fulcrum (E), situate above the tops of the vertical pipes and midway between them. They are arranged to be partly submerged whatever the water level in pipes B and C, in which they are free to move may be, thus causing the lever to take up a position of equilibrium under their displacing action, whatever may be the absolute or relative levels of the water in B and C, and to maintain this position unchanged during any variations of water level due to the filling up of the tank to which the treated liquor is led, below which tank the lower part of the apparatus must always be set. The position of the said lever will, however, be immediately varied by any relative change of level of the water in B and C caused by a change of velocity through the Venturi tube. When no flow occurs through the Venturi tube the height of the water columns is equal, and the apparatus being required to add no reagent under these conditions, it is set so as to be tilted into its extreme or *zero* position by adjustment of the displacers relative to the lever by means of the turnbuckle (K).

Unequal withdrawal of liquid around the two displacers will at once disturb the balance as soon as flow takes place in the Venturi tube, the unbuoyed weight of the one in B exceeding that of the one in C, and the lever in tilting to re-establish equilibrium will also turn the cylindrical vessel (H). This is mounted horizontally upon the lever, its axis coinciding with the pivot on which the lever turns, and is fed with reagent of a constant strength through an open slit across its top. A valve actuated by a float secures constancy of level of the reagent within the said cylinder. From the circumference of the vessel projects a spout (J) with a small orifice at the end, the lower edge of which having been placed, during the zero adjustment above described, just above the water level in (H), no flow of solution can occur in this position, corresponding to zero discharge through the Venturi tube. A disturbance of the lever, however small, will cause discharge of the reagent through the orifice into a cup (L), from which it is conveyed by a pipe to mix with the body of liquid to be treated at a convenient place on the down-stream side of the Venturi tube. It is due to the fixed and definite proportionality between the vertical motion of the orifice (J) (and therefore of the magnitude of the head causing flow through same) and the relative motion of the water in B and C that the accuracy of this apparatus is theoretically perfect, the factor determining the flow of solution being itself entirely governed by the flow of the liquid to be treated.

Certain small and unavoidable errors connected with the flow of water through an orifice and with the "Venturi effect" introduce a practical error which has been found as the result of careful tests made under the most extreme conditions of working, not to exceed 1·66 per cent. for an apparatus working on a large scale, substantially as that shown in the diagram. The flows of water (gallons per hour) and of chemical reagent recorded were as follows:—

Water.	Chemical Solution.	Per Cent.
640	19·8	3·09
1820	52·2	3·04
1820	57·2	3·14
2390	73·7	3·08

An apparatus for commercial purposes is about to be constructed, to deal with any quantity up to 600,000 gallons of liquid and 300 gallons of solution per hour. The best results will attend the adoption of a solution of the reagent of invariable strength, the orifice being proportioned to suit the flow of reagent desired. So long as an unchanged percentage of reagent is needed no adjustment of the apparatus will be required, but to provide for variation of the percentage to a known extent by each adjustment, a plate containing a series of suitable orifices, any one of which may be brought permanently into action to the exclusion of the remainder, is conveniently fitted at J. The need for this adjustment would be imperative in the case of a variation in the amount of impurity in the liquid to be treated.

The dimensions and cost of the apparatus are relatively small, even for the large scale cases mentioned.

The advantages arising from the adoption of such a means of regulating the mixing of reagents in comparatively small quantities may be of distinct value in the chemical and dyeing industries.

THE PAY OF THE PUBLIC ANALYST.

The *Lancet* of 9th March states:—

"The remuneration of the Public Analyst has seldom been upon a scale consistent with the training, skill, and experience which are required of him, but now that the practice of adulteration is becoming such a refinement, requiring a very elaborate series of operations for its detection, the scale of fees in many instances is wholly inadequate. There can be little doubt that modern methods of adulteration are often the product of a subtle scientific mind which discreditably turns its attention to the possibilities of eluding the control over the purity and quality of food, drugs, and drink provided by the Sale of Food and Drugs Acts."

THE PHYSICS AND CHEMISTRY OF COLLOIDS

By Emil Hatschek.

CHAPTER III. (*Continued.*)

This movement—of which no description will convey an adequate idea, but which can be easily observed in a suspension of gamboge with a $\frac{1}{8}''$ objective—is not confined to ultra-microscopic particles, but is observed with all small particles below $3\,\mu$ diameter. Its intensity decreases with increasing size, and particles above $3\,\mu$ are generally stationary in the microscopic field. While the Brownian movement may undoubtedly be considered as assisting to keep the disperse phase in a sol in suspension, it cannot be the chief factor, as suspensions of particles well below the limit size may settle rapidly, for instance, calcium carbonate particles of $2\,\mu$ diameter such as constitute the "causticizing mud."

We are accordingly compelled to seek the chief reason for the stability of sols in the electric charge of the particles, and a more detailed study of the suspensoids will supply very strong evidence in support of this view. The electric charge may be produced by a number of factors, of which at the moment we need only consider one, the well-known phenomenon of contact electrification. Any substance in contact with a liquid assumes an electric charge, and it is interesting to note here that this charge is, with an enormous majority of substances, *negative* if they are in contact with water. The particles of a coarse, *i.e.*, reversible, suspension are, it is almost needless to say, also charged, but owing to the comparatively small surface the total charge and the effect of this charge is excessively slight compared with the other forces acting on the particles. As their size decreases, the total surface, for a given mass, increases until, in typical sols, it attains very striking sizes. In one litre of gold sol containing 0·5 grammes of gold the surface gold-water is about *10 square metres*, while at the same time the mass of each particle has become so small, that the electric repulsion between neighbouring particles is nearly one hundred times greater than their weight. It is obvious that such a condition precludes approach between the particles and settlement, and that the system must be stable, until its electrical state is disturbed.

Before we proceed to study suspensoids in detail, it may be worth mentioning how the electric charge on the particles can be demonstrated. This can be done, for instance, by placing the sol to be examined into the bend of a U-tube (Fig. 6) and filling the limbs with pure water, into which dip electrodes connected to some source of current. The particles gradually wander into the water surrounding the pole of opposite sign, so that negatively charged particles wander to the anode.

Another very convenient method, permitting the use of small volumes of liquid is the microscopic method, as used first by Cotton and Mouton. An ordinary microscope slide (Fig. 7) is provided with a pair of electrodes of platinum foil, which are connected by suitable leads to a couple of cells or accumulators. A drop of the liquid under examination is placed on the slide so as to touch both electrodes and covered with a cover glass. The preparation is examined under the microscope—using one of the ultra-condensers described in the previous chapter, if necessary—and the particles are seen to travel to the anode, if negatively, or the cathode, if positively charged.

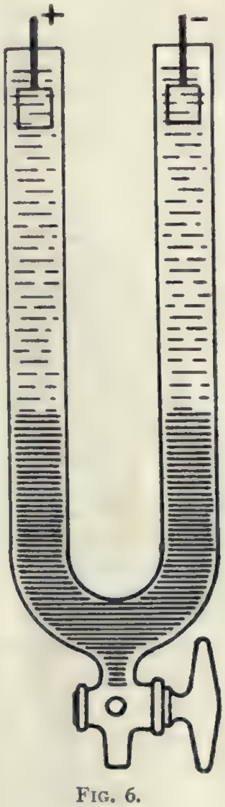


Fig. 6.

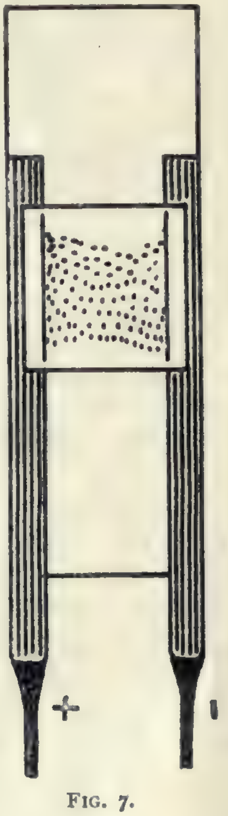


Fig. 7.

Both the U-tube and the microscopic method also permit the actual charge on a particle to be measured, by observing the rate of travel and the strength of the electric field, *i.e.*, the difference in voltage divided by the distance of the electrodes. We need only mention here that a very large number of different materials have been so examined, and that the charge carried by a particle is very much the same in all cases.

CHAPTER IV.

In the preceding chapter we have fully characterised the suspensoids as systems containing the disperse phase as solid particles below a certain size, in constant movement and electrically charged. A few typical suspensoids—the gold, silver, antimony and arsenic sulphide sols—have already been referred to in the first chapter, where directions are given for preparing them.

These directions have one feature in common: the metal is reduced or the sulphide produced by a suitable reaction in very dilute solution. This procedure is applicable in many cases, though not universally, and sols of silver, copper, mercury, platinum, palladium, etc., have been prepared by reducing very dilute solutions of their salts with a great variety of reducing agents, such as hydrogen, hydrazine and hydroxylamine compounds, acrolein, hypophosphorous acid, and many others. Many sulphides and haloid compounds can also be obtained in a similar fashion. The reason why all these processes can be carried out in very dilute solutions only is clear: we already know that the suspensoid sols are precipitated by varying, but always small, amounts of electrolytes. As practically all the reactions mentioned lead to the formation, not only of the disperse phase which it is desired to obtain, but also of electrolytes, it is obvious that the concentration of these must be kept below a certain limit, or, in other words, that it is necessary to work with very dilute solutions.

A number of other methods have been applied with considerable success, several of which may be classed together as "disintegration methods." The most important of these is that of Bredig, first published in 1898, which consists in producing a small electric arc between electrodes made of the metal which is to be dispersed, under water. With suitably proportioned electrodes, current strengths, and cooled liquid, sols of many metals can be prepared, including platinum, iridium, palladium, gold, silver, copper, lead and others. The method has been considerably developed and improved by Svedberg, who substituted for the arc an oscillating discharge between electrodes of aluminium or zinc (which resist disruption) between which the metal to be dispersed is suspended as foil. He also used, instead of water, a number of organic compounds, such as ether, pentane, isobutylalcohol, etc., and, by cooling with liquid air, was able to prepare sols of the alkali metals, barium, strontium, and many others. An interesting feature of many of these sols is their colour, which in most cases is the same as that of the vapour.

Another disintegration method, invented by Kuzel, and applied particularly to the metals of the bismuth and chromium groups, consists in grinding the material as fine as possible in ball mills and then treating it repeatedly and for many days alternately with strong alkali and acid. When these are finally replaced by water, the metal is found to be reduced to so fine a state that it forms a sol.

In a few cases no treatment at all is required, but the metal goes directly into colloidal solution on contact with water, or at least on boiling. Lead, *e.g.*, has been shown by Mme. Traube-Mengarini and A. Scala to form a sol at once on contact with distilled water: if, however, no precautions are taken to exclude oxygen, the dissolved lead is promptly transformed into hydroxide. The same investigators showed that a silver sol could also be obtained by boiling distilled water for some time in silver vessels; that copper sols are formed under the same conditions, has been known for some time.

A third procedure is that called by Graham "peptisation," in allusion to the transformation of insoluble into soluble compounds by digestion. An example will best illustrate the characteristic feature of this method, for instance, the production of a cadmium sulphide sol. The sulphide is precipitated from an ammoniacal solution of cadmium sulphate, washed and finally suspended in distilled water. If hydrogen sulphide is now passed through the water, the suspension gradually becomes milky and finally perfectly clear golden yellow with a slight red surface colour. The dissolved gas may be displaced by nitrogen, or removed by boiling, the sol being extremely stable.

Of all the striking properties of the suspensoid sols, their instability in the presence of electrolytes is probably the most striking, and has received a very large amount of attention and study, particularly from English investigators—Linder and Picton, Hardy, Burton, and others. To summarise their results, at the same time excluding matter which goes much beyond the scope of these articles, and is in part still highly controversial, it may be said that the first step in the coagulation of suspensoids is the neutralisation of their electric charges by that of the oppositely charged ions of the electrolyte. As most suspensoids are negatively charged, the active ion is accordingly the positive, or cation, of the electrolyte. Each electrolyte has to be present in a definite concentration to produce coagulation, and a very large number of investigations have been directed to ascertaining these minimum concentrations for various sols, and a large range of electrolytes. The subjoined table gives the results of one of the most extensive series by Freundlich. The sol was an $As_2 S_3$ sol, containing 7·539 millimoles (*i.e.*, 1·854 grammes) of the negatively charged sulphide per litre; the electrolyte concentrations are given in millimoles per litre:—

$K Cl$	49.5	$Mg Cl_2$	0.717	$Al Cl_3$	0.093
KNO_3	50.0	$Ca Cl_2$	0.649	$Al(NO_3)_3$	0.095
$NaCl$	51.0	$Ba Cl_2$	0.691		
$LiCl$	58.4	$Ba(NO_3)_2$	0.687		
$H Cl$	30.8				

The first column contains the electrolytes with monovalent, the second those with divalent, and the third those with trivalent cations. It will at once be noticed that—in each column—the quantity of electrolyte depends only on the cation: practically the same molar concentration of potassium chloride and nitrate, barium chloride and nitrate, and aluminium chloride and nitrate produces the same effect, which therefore in each case depends only on the amount of $K^{\cdot}$, $Ba^{\cdot\cdot}$ and $Al^{\cdot\cdot\cdot}$ present. A very striking difference, however, shows itself between salts containing cations of different valency, that is between the three columns of the table. The concentration of the monovalent cations is roughly 70-80 times greater than that of the divalent, and 600 times greater than that of the trivalent cation. This phenomenon, which Hardy was the first to study, is probably best explained by the theory propounded by Freundlich, to which we shall have occasion to refer when considering adsorption.

An equally important point in this connection—the comparative behaviour of ions of different valency—was first investigated by Linder and Picton. When the electrolyte is added to the sol, the particles are discharged and, as they no longer repel one another, are free to approach and to form larger aggregates, which settle more or less rapidly. These precipitates always contain some of the precipitating cation, and investigation shows that the amounts of different cations found are equivalent. This fact—which is somewhat surprising in view of the great difference in concentration—becomes intelligible at once when we remember that equivalent quantities of all ions carry the same charge, and are therefore able to neutralize the same amount of oppositely charged suspensoid particles.

It is by no means necessary that the precipitating ions should be supplied in the form of an electrolyte. The arsenious sulphide sol, for instance, can be coagulated by passing through it air ionised by the brush discharge from a Wimshurst machine, and other ionising agencies, such as Röntgen rays or ultra-violet light are equally effective.

We have so far referred exclusively to sols containing only the disperse phase and the small amount of electrolytes produced by the reaction which gives rise to the formation of the disperse phase. Many reactions, however, for instance, that between lead compounds and chromates, or barium salts and sulphates, never lead to sol formation, even if carried out in very great dilution in pure aqueous solutions. In other cases such reactions do produce sols, which, however, are very unstable. It has been known for some time that the addition of very small amounts of colloids belonging to the second or "emulsoid" groups greatly increased the stability of sols: Faraday observed, that the gold sol which he obtained by reducing gold chloride solution with a solution of phosphorus in ether could be kept unaltered much longer if "a little jelly" was added to it. Similarly, if the colloid is added beforehand to one of the reacting solutions, insoluble precipitates can be obtained in so fine a state of dispersion that they form sols: thus a small addition of casein makes it possible to obtain sols of lead chromate, barium sulphate, etc. The sols so obtained also require very much larger amounts of electrolytes for precipitation than do suspensoids without such additions, which are accordingly in this connection described as "protective colloids." They all belong to the emulsoids, of which we already know that they are much less sensitive to electrolytes than the suspensoids, and their action in protecting the latter is probably best explained by Bechhold's assumption that each particle of the suspensoid surrounds itself with a layer of the emulsoid and then possesses the electrical properties of the latter.

Although many readily available substances, such as gelatine, albumin, casein, isinglass, etc., can be used as protective colloids, one group of compounds has acquired great prominence during the last few years. These are certain products of the hydrolysis of albumen by alkalies, first described by Paal and his collaborators as "protalbinic" and "lysalbinic" acids, and used by them in the preparation of a very large number of different metal sols. These show very great stability, and the silver mercury sols, for instance, can be evaporated to dryness and then readily re-dissolved in water.

The "protective" effect of different emulsoids varies between very wide limits, and may perhaps offer one of the most delicate means for their differentiation. It has been studied systematically by Zsigmondy, who determined the quantity of colloid just necessary to protect a definite volume of a standard gold sol from coagulation by a given quantity of sodium chloride. The relative figures vary from 0·005 for gelatine, 0·02 for isinglass, and 0·2 for egg albumin, to 12 for dextrine and 25 for potato starch. They are usually referred to as the "gold values" or "gold figures" of the colloids.

(*To be continued.*)

PERSONAL AND OTHER NOTES.

In view of the resignation by Sir Edward Thorpe of the Professorship of Chemistry in the Imperial College of Science and Technology at the end of the present session, the Governors have appointed Dr. H. Brereton Baker, M.A., D.Sc. (Oxon), F.R.S., to succeed him.

Dr. Baker at present holds the post of Lee's Reader in Chemistry at the University of Oxford. He has published a number of memoirs, more particularly on inorganic chemistry, and he is specially well known for his discoveries of the influence of minute traces of moisture on the course of chemical change, work for which the Longstaff medal has just been awarded to him by the Chemical Society.

Prof. F. G. Donnan, M.A., Ph.D., of Liverpool University, will succeed Sir W. Ramsay at University College, London.

REVIEWS OF BOOKS.

PAINT TECHNOLOGY AND TESTS. By Henry A. Gardner. McGRAW HILL BOOK COMPANY. New York and London. 219 Plates. 2 Figures. Pages 266 + viii, Chapters XVII. Price 12s. 6d. net.

THE book under review marks a new era in the technology of paints, and is a welcome record of the introduction of scientific enquiry into the respective merits and demerits of different paints, having due regard to the various influences to which they are submitted after application for the protection and decoration of surfaces, supplemented by investigations as to the physical and chemical nature of the materials entering into the composition of paints. The experiments described have been carried out under the auspices of the Educational Bureau of the Paint Manufacturers' Association and the International Association of Master House Painters and Decorators of the United States and Canada, and can be divided into two classes :—

1. Laboratory investigations from a physical and chemical standpoint.
2. Field exposure tests in different districts in order to observe the effect of different climatic and atmospheric conditions.

Chapters I. to V. deal with the first enquiry, and are of considerable value, inasmuch as they contain useful data, together with descriptions of some novel laboratory methods and appliances. A considerable amount of space is devoted to the description of linseed oil and its substitutes, which shows distinct evidence that the recent high prices of linseed oil has been an incentive towards the technical application of substitutes, and, further, that it is by no means certain that linseed oil will always occupy its present unique position.

A curious mistake occurs on page 27, where Blackler is credited with having carried out experiments on the auto-oxidation theory of linseed oil. Blackler summarised the results of various experiments, whilst the auto-oxidation theory and the experiments are due to Genthe (*Zeits für Angew Chem.*, 1906, *19*, 2087).

A series of interesting results of Co-operative Drying Tests occupy pages 32-41. These would have been more easily comparable had the figures been plotted in curve form instead of the tabulated statements presented.

On page 42 it is stated that corroded white lead contains about 85% lead oxide and 15% carbon dioxide and water. These figures represent a composition seldom, if ever, found in white lead.

Page 43 has an excellent photograph of normal lead carbonate sometimes found in over-corroded white lead.

Basic sulphate of lead is treated on page 46, and is described as non-poisonous, a statement not in accordance with facts, and one likely to put users in a wrong and dangerous position.

A description is given for the preparation of paint films, and this is of considerable value, though it is by no means certain that absolute knowledge can be obtained by the examination of a film when removed from the surface it is intended to protect. Of much more value are the results obtained *in situ*, and this should be borne in mind when considering results obtained by the ingenious film testing apparatus described.

The permeability experiments described on pages 72-74 are of questionable value, seeing that the conditions are abnormal. In practice paints are not submitted to reagents of the type of ferrous sulphate ammonium chloride or ferric chloride; further, these reagents are not without action on some of the bases employed. The increased resistance obtained by the addition of certain gums to paint vehicles is of great importance, and indicate that the life of a paint film might be considerably lengthened by the use of such materials.

The law of minimum voids and the theory of reinforcement, as applied to paint films, is fully treated. A serious consideration of this theory is recommended to those interested in the subject, seeing that the field results all point to the durability of reinforced films.

Pages 105-251 contain a detailed account of the field work, and a mass of valuable results are given with which it is impossible to deal in detail. Such results constitute the first series obtained from an organised enquiry on a large scale, and are quite unique in their scope. It is unfortunate that owing to climatic conditions such results are not capable of world-wide application, yet it is to be hoped that they may be an incentive to other countries to face the question, and determine by scientific enquiry the respective merits and demerits of the paints now in use.

The photographic part of the book is overdone. The microscopic reproductions are generally good, but those showing machinery, etc., are so devoid of detail as to be of very little value.

The book is interesting throughout, and one has nothing but praise for the spirit in which it is written, though—as must be the case with pioneer work—there is much to criticise. It is a work which demands careful study by those interested in the manufacture of paints or their application.

C. A. K.

"ASSAYING AND METALLURGICAL ANALYSIS."

By E. L. Rhead and A. Humboldt Sexton. Longmans, Green & Co., London, 1911. 2nd Edition. Pages 451+x, including Appendices and Index. Divided into 3 Parts and 38 Sections, with numerous Illustrations. Price 12s. 6d. net.

This work is divided into three parts, the first dealing with the usual laboratory appliances and general processes, the second treating, under the name of each individual metal, of the natural materials and products in which it usually occurs, including a description, in most cases, of the commoner ores and minerals, so as to assist the chemist in actual identifications, and a concise account of the dry tests and chief chemical reactions involved. Then follows a description of the dry assay methods and the wet assay by gravemetric, volumetric and colourimetric determinations. The third part of the book deals with the metallurgical analyses of the chief commercial metals and alloys.

In the description of the wet assay of these metals, usually met with in commerce in a state of great purity, sufficient emphasis is not laid on the importance of the presence of minute quantities of impurities. In fact, the methods proposed are not suitable for determining such impurities as often exist in small fractions of 0·1%.

The electrolytic estimation of Cu is hardly as fully described as its importance deserves, and is not sufficiently up to date, no mention being made of the rapid methods so essential to the works chemist.

Many of the methods of dealing with alloys can hardly be regarded as satisfactory, and if adopted might be liable to produce unfavourable results.

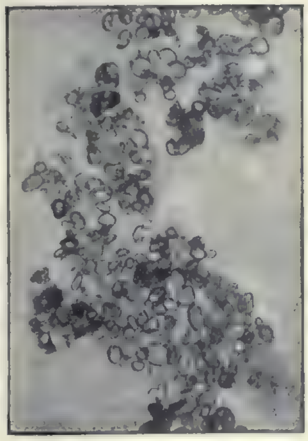
The use of certain salts of the fixed alkalies as reagents might well have been replaced by their respective ammonium salts, the advantage in the use of the same being sufficiently obvious.

For the chemist used to dry assay methods the work is to be commended, but for the more precise determination of the constituents of alloys the text must be read with judgment and discernment.

H. F. K.

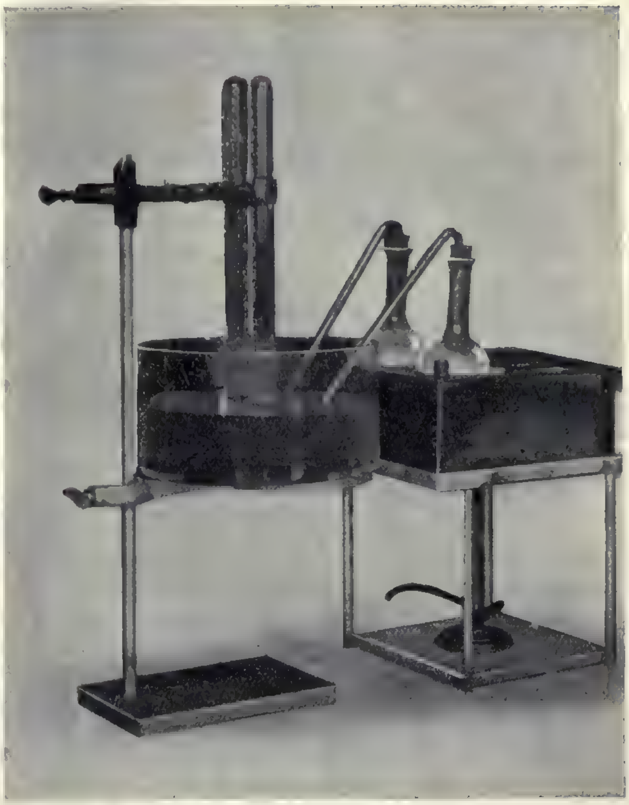
"THE CHEMISTRY OF BREAD-MAKING."

By J. Grant. E. Arnold, London, 1912. Pages 224+vi, including Index. 4 Plates. Price 5s. net



Barley Starch.

The author advises that this book should be read in conjunction with text-books on chemistry, biology, etc. It deals in a general way with such matters as organic constituents of the cereals, milling, malts, ferments, bacteria, etc., and then describes in some detail the actual bread-making processes. The important subject of antiseptics and bakehouse hygiene are discussed, and a chapter is devoted to the analysis of cereal foods; and this one is perhaps the best in the book, which contains many examples of analytical figures. The book is well illustrated, as will be seen from the accompanying blocks, although one might have wished that the illustrations of machinery had been more generally selected.



Gas Evolving Power of Yeast.

It serves a purpose in supplying to the general reader an elementary account of the operations and control of bread-making.

Books Received.

"SCIENCE PROGRESS." John Murray, January, 1912. Price 5/- net.

"THE TECHNOLOGY OF BREAD-MAKING," by W. and W. C. Jago. Simpkin, Marshall, Hamilton, Kent & Co., Ltd., 1911. Pages 908+vi, including Index, numerous Illustrations. Price 21/- net.

"PRÜFUNG DER CHEMISCHEN REAGENZIEN AUF REINHEIT," by E. Merck. 2nd Edition. Pages 325+iv. Darmstadt, 1912.

"THE GEO-CHEMICAL INTERPRETATION OF WATER ANALYSES," by Chase Palmer. Bulletin 479. United States Geological Survey. Pages 31. Government Printing Office, Washington, 1911.

"LECTURES ON CEMENT," by Bertram Blount. Published by the Institute of Chemistry, 1912. Pages 68, including 4 Appendices and 6 Illustrations. Price 2/6.

"HISTORICAL PAPERS ON MODERN EXPLOSIVES," by George W. MacDonald. Pages 192+x, with Index. Whittaker & Co., London, 1912. Chapters XXVII. Price 7/6 net.

NEW METHODS OF ANALYSIS.

AUTOMATIC ANALYSIS.

By Charles A. Keane, D.Sc., Ph.D., F.I.C.

The introduction of automatic analytical apparatus marks an important advance in the methods for controlling the conditions of work in manufacturing operations. In chemical industries, the control, by means of analysis, of the re-actions concerned and of the efficiency of the plant employed, forms an essential part of the routine operations in all works and the substitution of mechanical appliances for a portion of the labours of the chemist, cannot but prove a welcome adjunct to his laboratory equipment. Such appliances offer the further advantages that they can furnish more complete data than is feasible with the ordinary methods of manual analysis, and that the determinations are automatically recorded for inspection and reference. In addition, the results are available for the continuous observation of the workmen concerned in a form which they can fully understand and thus serve as a stimulating influence towards the efficiency of their work; the fact that in some cases the men are given a bonus based on the automatic records of their labour is the best evidence of the economic value of this factor, apart from its moral effect.

Automatic methods of analysis are, as yet, restricted to gases, those products which, chiefly owing to their invisibility, were the last to be recognised as of importance in the control of chemical operations. As is natural, the methods have been first applied to the estimation of gases which either can be completely removed from the associated components of a gaseous mixture by simple means, or the presence of which causes a marked quantitative difference in the physical properties of the mixture.

The economic importance of the fullest possible control of the combustion of fuel combined with the simplicity of the estimation of carbon dioxide, thus led initially to the construction of apparatus for automatic analysis, but the method has already advanced towards other problems such as the determination of sulphur dioxide in the wood-pulp industry, of carbon dioxide in the manufacture of sodium carbonate by the ammonia-soda process, of chlorine, and of carbon monoxide; it holds out the possibility of further important applications in many chemical industries and methods of investigation to which it has not yet been adapted, and from this standpoint merits the best attention of chemists. Whilst the methods to be described are those concerned with the determination of carbon dioxide and of other gases that can be similarly estimated, for which the forms of apparatus now in use were specially constructed, the details may be helpful in indicating the possibility of other applications.

Automatic Apparatus for the Estimation of Carbon Dioxide.

To obtain a reliable criterion of the course of a combustion it is well known that so-called "average samples," even when a constant method of suction is used for drawing the sample, are unsatisfactory, as variations in composition that may occur during the period of sampling are not detected; to gauge the efficiency of the stoking, or of any special method of combustion adopted, the only satisfactory plan of analysis is to take a series of separate samples at successive short intervals. The work thus involved is considerable and the advantages offered by an automatic apparatus for this purpose as a labour-saving appliance needs no comment.

The forms of apparatus hitherto introduced for the automatic analysis of furnace gases may be divided into those in which the contained carbon dioxide is removed by absorption and those in which the determination is effected by means of such physical properties as the specific gravity or the refractive power. Of these, the former have proved the more generally applicable. Although, in some respects, less accurate than the latter, they are sufficiently so for the analytical control required, and respond satisfactorily to variations in the composition of the gases examined. Very marked ingenuity has been expended on the construction of the apparatus for this absorptiometric method of estimation, and many forms have been devised; though differing in detail, and in some cases in principle, they all depend upon the absorption of the carbon dioxide and the subsequent recording of the decrease in volume effected by the absorption. The following description is restricted to those forms which offer special points of interest, and which have been introduced into technical practice.

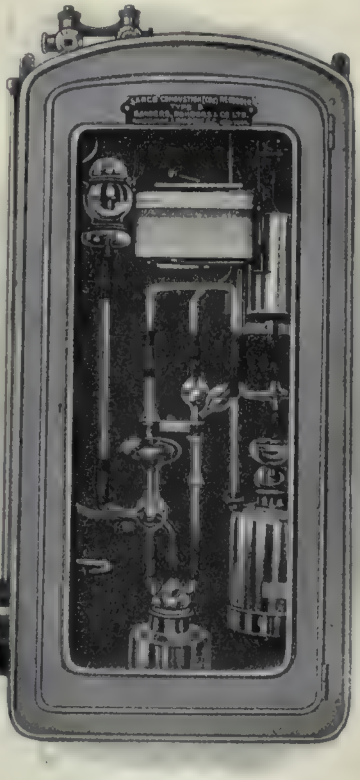


Fig. 1.

In all cases the sample of gas to be analysed is drawn, by means of a suitable water aspirator, into the apparatus, after previously passing through a filter to remove any suspended impurities that may be present. Except in the case of the Autolysator, this same aspirator also serves to actuate the mechanism of the apparatus, which is so arranged that the containing vessel into which the gas is first drawn is emptied intermittently by means of a syphon-overflow pipe; by this means the gas is transferred to a vessel in which the carbon dioxide is absorbed and thence to a second containing vessel which allows of the recording of the change in volume effected by the absorption of the carbon dioxide. A series of intermittent determinations are thus obtained, the speed of which can be regulated by varying the water supply of the aspirator; this can be adjusted so that from 15 to 30 determinations can be made per hour. The various forms of apparatus differ chiefly in the method adopted for recording the change in volume effected by the absorption. In the Autolysator a different principle is adopted, the pressure of the gas before and after the absorption being measured by means of differential manometers; a continuous instead of an intermittent record of the proportion of carbon dioxide is thus obtained.

1. The "Sarco" Combustion Recorder.[1]

This apparatus, which was designed by Arndt, was first introduced under the name of the "Ados" recorder. It is shown in its most recent form in Fig. 1; Fig. 2 illustrates the method of working. The parts are all made of glass, and are connected by rubber tubing. The central bulb-shaped vessel, 67, serves as the burette into which 100 c.c. of the sample are drawn intermittently and then discharged through a solution of caustic potash contained in the vessel 94; the residual gas then passes to the two floats 27 and 18, on the right-hand side of the upper part of the diagram, which are so arranged that the inner float (27) receives only 20% of the whole of the sample.

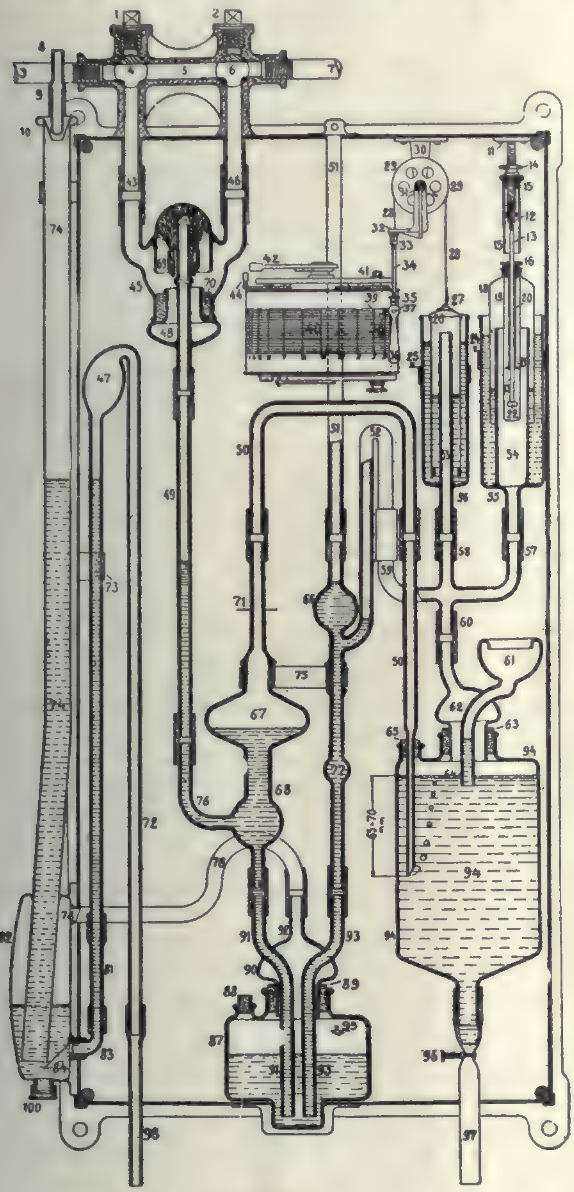


FIG. 2.

(To be continued.)

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[1] Supplied by Messrs. Sanders, Rehders & Co., 108 Fenchurch Street, London, E.C.

COMMERCIAL AND GENERAL NOTES.

Germany's Chemical Trade in 1911.

According to a report of the Frankfort Chamber of Commerce on the German chemical trade during the past year, the volume of the business was quite satisfactory, but the manufacturers had reason to complain of the inadequate prices realised for their products. These are due to the growing competition which made it even necessary to reduce prices of products under the control of conventions. The report states that the influence of the war between Turkey and Italy was beginning to be felt, as well as that of the Chinese revolution, both these disturbances causing the demand from the affected markets to slacken. A diminution of the chemical exports to those countries must be expected in the current year. The export trade has to face considerable obstacles in the shape of competition from the home manufacturers in the principal export countries. A serious blow was dealt to German exporters of chemicals to the land of the Mikado by the high tariff on imported chemicals which came into force last summer. In common with the chemical industries of other countries, the general expenses of the German manufacturers are constantly increasing. The advanced cost of living makes corresponding advances of wages necessary, if labour difficulties are to be prevented. Heavy import duties on chemical products in several countries which used to take great quantities of German chemicals, prove a serious handicap to the export trade, the prospects of which are none too promising.

Projected Alteration of the Chemical Duties in the United States.

The Democratic members of the Ways and Means Committee of the House have prepared a revision of the chemical schedule, which radically alters rates of duty, particularly on heavy chemicals. The explosive manufacturing industry is also considerably affected by the new rates, and the same is true of various other branches of the business. The Bill has been ratified by the Democratic caucus, and will shortly be debated and passed by the House. What will happen to it in the Senate is uncertain. Already, however, plans are spoken of for consolidating it with the pending Steel Bill, and for passing the two as one measure. This would practically insure a Presidential veto, it is understood.

The chief significance of the new schedule is found in its radical change of classifications and arrangement of articles. On this subject the report prepared by the Committee says:—

"The chemical industry, on account of its importance, was in 1883 given a special schedule in the tariff, and the present classifications are, with few exceptions, the same as when the schedule was first constructed. The industry has undergone a complete transformation since then, and it is not surprising that the classification items of more than a quarter of a century ago are out of adjustment with the present conditions. With a view to improving the antiquated condition of schedule A, and of having it conform to industrial and administrative requirements, the Committee has given much time to the consideration of the subject, and believes that the Bill is in every way a thorough and scientific revision of the chemical schedule."

The Development of the Chemical Industry in Japan.

In consequence of the high import duties which the new Japanese tariff imposes on foreign chemical products, the home manufacturers are able to compete successfully with European and American exporters and develop their trade at home and abroad. Though practically in their infancy, some branches of the chemical industry show rapid growth. This is the case with chemical fertilizers, which are consumed in enormous quantities in Japan. An article of considerable importance is superphosphate, although its use in great quantities is of comparatively recent date. During the Russian-Japanese war the supply of oil-cake from North China was practically stopped, which brought superphosphate into prominence. It is made from phosphorite, an impure massive form of apatite, the chief source of which are the Christmas and Gilbert Islands in the Pacific. Not only do the Japanese manufacturers satisfy the greater part of the home demand, but they also export considerable quantities. Some of their works employ over 300 workmen. The production of chloride of lime, caustic soda, etc., is constantly and rapidly increasing.

Imported calcium carbide has almost completely disappeared from the Japanese market on account of the growing home production of four large firms. The preparation of iodine from seaweeds represents an important branch of the chemical industry of Tokio and Osaka. It may be mentioned that the Japanese iodine manufacturers do not belong to the International Iodine Syndicate.

The Utilisation of Henequin Waste for the Production of Alcohol.

The utilisation of the residue of fibres is a question of great economical importance, and many inventors are constantly experimenting with a view of discovering new methods of producing "something out of nothing," so to speak. A native of Tabasco in Mexico, who has been resident for some years in Yukatan, is credited with having discovered a method for utilising the residue of henequin or sisal hemp for the production of alcohol. In the process of extracting the fibre the fleshy part of the leaf is scraped off by machinery, and this, with the exception of a small portion used in the manufacture of packing-paper, has been, heretofore, simply thrown on the rubbish heap. After many years of experimenting it has been found that this waste, together with the juice which escapes during the extraction of the fibre, will produce a good, useful alcohol. The raw material is placed in tanks with water and allowed to ferment for some time. After this it passes into specially arranged stills. Recent tests, made in the presence of many prominent business men in Yukatan, were said to have given very creditable results. With the immense territory devoted to the culture of the henequin plant in Yukatan, and the yearly increase in the number of acres planted in that State, there should be a large supply of the raw material. At the same time, the multiplicity of uses to which alcohol is now put ensures a constant demand.

International Technical Convention for Industrial Hygiene and the Prevention of Accidents.

An interesting Convention under the protectorate of the King of Italy, has been arranged to take place in Milan, during the last week of May. The subjects for discussion, which have just been published, indicate the versatile and interesting nature of the undertaking, comprising, as they do, many matters of great industrial importance. There will be Papers read on "Preventative Measures for the Protection of Life against the Danger of Short Circuits"; appliances for use in rolling mills and rubber works will be shown and described; the proper ventilation and dust-prevention in cotton mills and the improvement of the air in dyeing and finishing works will be discussed, as well as many other subjects of general interest. Further details of the Convention may be obtained by writing to the editor of *Zeitschrift fur Gewerbe-Hygiene,* Mr. Victor Steiner, Wien 11, Am Tabor 18.

Calcium Cyanamide for the Extraction of Ores.

Calcium cyanamide which is principally used as a fertilizer material, may serve for the partial substitution for sodium and potassium cyanide in the extraction of gold from low-grade ores. According to the invention of Mining Engineer Clancy, a mixture of calcium cyanamide, potassium cyanide, potassium sulphocyanide, and potassium iodide, is electrolyzed. The Ajax Gold Mining Company of Victor, in Colorado, have been operating their 200 ton mill using this process, and the chemical consumption is reported to have been very low.

The Use of Shellac in Food Products.

In a circular just issued by the Bureau of Chemistry, through the Office of the Secretary of Agriculture, there is a discussion of arsenic in connection with the use of shellac in food products. The circular says:—"Orpiment, the yellow sulphide of arsenic, is very generally added to shellac in India, for the purpose of rendering the product opaque, and at the same time producing the light-straw colour characteristic of the higher grades. This is of interest to the food chemist, the health official, and the consumer, for shellac is used as a coating for certain food products, such as some kind of confectionery and bakers' products, and is largely used as a varnish on receptacles and containers of various kinds in many lines of food manufacture. The brewing industry is a very large user of shellac, the products of many breweries being held in shellac containers from the time the wort leaves the brew kettle, throughout the fermentation and ageing processes, until the consumer's glass is drawn 'from the wood'—that is, a shellac-lined cask. Fermentation tanks are almost universally shellac-varnished, several coats being applied once a year or oftener."

The circular contains the analysis of a number of samples of shellac obtained at breweries at random, and states that the data show that all of the samples examined contained arsenic, and adds:—"The addition of orpiment to shellac appears to be wholly unjustifiable. The person using this shellac, besides being misled as to its quality, unwittingly uses a product containing arsenic, which in the case of a manufacturer of foods, is a most serious matter from either an ethical or a commercial viewpoint."

An American Fertilizer Exhibition.

Under the management of the trade paper, *The American Fertilizer*, the second annual exhibition of fertilizer machinery, plant equipment, fertilizing materials, chemicals, etc., will be held at Atlantic City, N.J., from July 15th to July 19th inclusive. At the same time and place the Nineteenth Annual Convention of the National Fertilizer Association will take place, an event which will draw a large attendance of people interested in the industry of chemical manures, thereby making the exhibition of substantial value to those who wish to place their goods before the fertilizer trade. The official prospectus and full details will be posted on application to the publishers of the above-named paper, at 1010, Arch Street, Philadelphia, Pa., U.S.A.

M. L.

Institute of Chemistry.

Dr. George Beilby, F.R.S., the retiring President, delivered his address at the Annual Meeting on 1st March. He showed that during his period of office (1909-12), the Institute had increased by 102 members and 36 students, while the number of candidates for examination during the same period had increased by about 20. The scheme for raising a fund for new buildings for the Institute had made substantial progress and had reached the sum of over £8,500 of the £15,000 considered necessary for the erection of a simple but dignified building, suitable for carrying on the work of the Institute. Speaking of the prospects of the profession of chemistry, he believed that there was plenty of room for men of the right stamp, both in educational and industrial work. The Institute had been able to secure appointments for many young members of the profession, and, indeed, lately it had been difficult to find candidates for appointments offering quite good commencing salaries and fair prospects. Touching on the difficulties which confront public analysts and private practitioners, he referred to the attempts made on the part of certain local authorities to lower the status of the professional chemist by offering appointments at ridiculous remuneration. The Institute had decided to take a new and somewhat drastic step by issuing a notice to Fellows and Associates, advising them not to apply for appointments advertised by the Metropolitan Boroughs of Lambeth and Wandsworth, both of which at the present time seek to appoint a public analyst who will be required to provide a laboratory duly equipped, and a deputy, and to examine possibly as many as two thousand samples for £500 per annum; while the County of Antrim seek to appoint a public analyst to examine an indefinite number of samples, almost certainly over 800 a year, at a salary of £150. The more enlightened municipal bodies realise that the proper administration of important statutes, such as the Sale of Food and Drugs Act, cannot be expected unless they succeed in attracting to their appointments men of competence and integrity, and, moreover, men who can hold their own as responsible representative officers of their authorities. The Act is as much a statute against fraud as in the interests of public health, and it must be clearly understood that the public analyst is in no way subject to the control of the Medical Officer of Health. It was a false notion that medical men were capable of controlling chemical laboratories. Very few of them possessed anything approaching a competent knowledge of chemistry in any one of its branches, and it was astonishing to find Government authorities in some of our overseas dominions requiring doctors of medicine to supervise qualified professional chemists engaged in laboratories mainly devoted to the analysis of metals and ores. Dr. Beilby referred to important changes which were being made in educational appointments, particularly the Chairs of Chemistry at the Royal College of Science, Dublin, Oxford University, and University College, London, indicating how men who had achieved great things were making way for the younger generation of chemists, to whom we look to maintain the honour of the British school of chemistry, to which their predecessors had contributed so much. During the past year the Council had inaugurated a new scheme of lectures, mainly intended to help registered students and the younger members, such lectures being given by acknowledged experts in various branches and illustrating the actual work of practice as distinct from purely academic training.

Dr. George Beilby, F.R.S., Professor Percy F. Frankland, F.R.S., Mr. David Howard, and Sir William Tilden, F.R.S., were declared elected as Censors.

The President and Officers for the ensuing year are as follows:—President—Raphael Meldola, D.Sc., LL.D., F.R.S.; Vice-Presidents—George Thomas Beilby, LL.D., F.R.S., Frank Clowes, D.Sc., George McGowan, Ph.D., Sir Alexander Pedler, C.I.E., F.R.S., John Millar Thomson, LL.D., F.R.S., Sir William Augustus Tilden, D.Sc., LL.D., F.R.S.; Hon. Treasurer—Alfred Gordon Salamon, A.R.S.M.; Members of Council—Francis William Frederick Arnaud, Edward John Bevan, Bertram Blount, Arthur George Bloxam, James Connah, B.Sc., William Salvador Curphey, Cyril Dickinson, B.Sc., James Johnston Dobbie, Ph.D., LL.D., F.R.S., William Porter Dreaper, Martin Onslow Forster, D.Sc., F.R.S., John Alfred Foster, Sir Richard Garton, Frank William Harbord, A.R.S.M., Otto Hehner, Gordon Wickham Monier-Williams, B.A., Ph.D., William Henry Perkin, LL.D., Ph.D., F.R.S., Thomas Slater Price, D.Sc., Ph.D., Charles Proctor, Sir Boverton Redwood, Bart., D.Sc., Henry Droop Richmond, Clarence Arthur Seyler, B.Sc., Alfred Smetham, Thomas Stenhouse, Jr., B.Sc., A.R.S.M., Oliver Trigger, Edward William Voelcker, A.R.S.M., John White, Sydney Young, D.Sc., F.R.S.

YEAR'S RUBBER EXPORTS FROM THE F.M.S.

According to information given by the Federated Malay States Government to the Malay States Information Agency, the exports of plantation rubber from the Federated Malay States for the month of December amounted to 2,147,859 lb., making a total for the year of 19,695,330 lb. Appended are the comparative statistics for the corresponding period of 1909 and 1910:—

	1909. lbs.	1910. lbs.	1911. lbs.
January	345,593	768,743	1,329,170
February	361,425	728,458	1,490,849
March	441,251	899,383	1,916,219
April	429,056	1,123,097	1,235,917
May	399,573	877,435	1,147,488
June	486,343	879,675	1,229,754
July	535,187	971,469	1,581,993
August	448,910	981,022	1,651,845
September	602,944	1,110,476	1,677,062
October	781,541	1,484,847	2,182,857
November	610,589	1,153,137	2,104,317
December	645,403	1,234,669	2,147,859
Total	6,087,815	12,212,411	19,695,330

These statistics refer to the Federated Malay States only, and do not include the total export of Plantation Rubber in the Malay Peninsula.

In 1906 the total export from the Straits Settlements and F.M.S. ports amounted to only 1,035,601 lb., valued at £399,000 sterling. In 1909 the export had risen to 6,112,023 lb., valued at £2,340,000, and last year the total export of 12,245,864 lb. represented a value of no less than £5,695,000. Roughly speaking the export from British Malaya has doubled itself every year; but a glance at the F.M.S. statistics will show that last year, so far as the Federated States are concerned, there was a check to this rate of progression, though the figures still show a handsome increase on the export in 1910.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by Mr. John E. Raworth, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

25573/10. G. B. Livingston and W. D. Cairney, Glasgow. *Treatment of Latex.* 3 November, 1910.

The latex obtained from rubber guttapercha, balata and analogous trees is brought into contact with a mixture of ethyl alcohol and methyl alcohol and aldehyde, for example, acetic aldehyde, or with ethyl alcohol and aldehyde, for example, acetic aldehyde, whereby coagulation of the rubber latex and separation of the rubber or analogous substance is at once effected. The latex is sprayed or distributed over and into such spirit mixture, so as to bring its constituent parts into intimate contact with the spirit mixture. (3 claims.)

2836/11. A. T. Cocking and Kynoch, Ltd., Birmingham. *Explosives.* 3 February, 1911.

A process for the production of nitro bodies suitable for use as, or in the production of, explosives, consists, according to this invention, in nitrating a solution of a sugar or mixture of sugars in glycerine by the employment of a water free mixture of acids, such as is used in the present processes for the nitration of glycerine. (7 claims.)

2962/11. E. W. Quirin, Mansfield, Mass., U.S.A., and J. H. Bannon, Rochester, New Hampshire, U.S.A. *Treating Leather.* 6 February, 1911.

Leather, canvas or other fibrous material is impregnated with rubber, in accordance with this invention, by placing the material along with a solution of rubber in the chamber of a movable receptacle, and revolving the receptacle at such a high rate of speed that the rubber is forced by centrifugal action into the interstices of the material. (1 claim.)

7317/11. W. H. Staynes, Leicester. *Leather Treatment.* 23 March, 1911.

The invention relates to machinery employed in the manufacture of leather, and consists of a roll or cylinder provided with a series of ribs having abrasive working faces particularly adapted for use in what is known as the buffing operation, *i.e.*, of removing by abrading the grain side of the hide or skin. Such a roll or cylinder may be made of wood, with the ribs or bars cut or otherwise formed on the face thereof, and the face of the ribs or bars is covered with abrasive material, such as sandpaper, secured thereon by cement. For the buffing operation, the ribs or bars are arranged in series, converging to a point approximating a V, so that as the roller revolves the apices of the bars act on the centre of the hide or skin, and the divergence of the bars gradually buffs or abrades the skin towards the outer edges of the same. (2 claims. 3 Figs.)

1194/11. T. Chandelon, Liège, Belgium. *Guncotton.* Dated under International Convention as 17 May, 1910.

The invention relates to a process of treating guncotton for the purpose of increasing its solubility in its various solvents, and consists in submitting it to the combined action of heat and pressure, in the presence of an acid. The following is an example of the method of operation:—The guncotton on leaving the nitration bath is freed from the excess of acid according to the usual methods. After this treatment, there still remains a considerable percentage of acid, which is reduced by agitating the guncotton in a quantity of water. The guncotton then is drained or dried moderately and introduced into an autoclave, which is raised to a temperature of from 104° to 140° C., according to the solubility desired, pressure varying in accordance with the temperature between 1¼ and 3½ atmospheres. (2 claims.)

20804/11. A. Thorpe and N. V. C. Barton, London. *Sterilising and Preserving Milk.* 20 September, 1911.

The object of the invention is to render a mixture of borax and boric acid in an amorphous form, and used for the purpose of preserving cream and butter, more soluble or completely soluble, and to produce it in such a form that the user will not accidentally use a greater quantity than is allowed by law. According to this invention, the mixture is submitted to a pressure of about 140 lbs. to the square inch; the particles are flattened or flaked so that the liquid can very readily attack every part of them. The mixture is subjected to pressure in a die, thus producing a tablet, and if the weight of the materials placed in the die be carefully calculated, one tablet will give the correct proportion of preservative for a certain quantity. (1 claim.)

21567/11. F. W. Golby, London. (Communication from The Moore Architectural and Engineering Company, Akron, Ohio, U.S.A.) *Reclaiming Rubber Waste.* 30 September, 1911.

In this process, rubber waste, together with a solution containing caustic alkali and ferric hydrate, is placed in a closed receptacle and then subjected to pressure and heat. The rubber waste and solution are then agitated and subjected to the action of an electric current, the direction of the flow of which is periodically reversed. After the rubber waste has been thus treated with the reclaiming agents, the entire mass is thoroughly washed to remove all traces of the reclaiming agents from the rubber. (4 claims. 1 Fig.)

27900/11. A. Wolff, Cologne, Germany. *Chrome Leather.* 12 December, 1911.

Certain salts of chromium have already been used for tanning hides. The applicant has discovered that a solution of chromium formate, which is easily soluble in water, is more suitable for tanning hides than the other chromium salts hitherto employed. In carrying out the tanning process, a solution of pure chromium formate is employed, preferably produced by the double decomposition of a concentrated solution of chromium sulphate with sodium formate, whereupon the sodium sulphate which is formed and precipitated is separated from the solution by centrifugal action. Either a neutral or a basic solution of chromium sulphate may be used for the preparation of the chromium formate. In the tanning process, no mineral acid is liberated, only formic acid being so liberated. (3 claims.)

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"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

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FUTURE FUEL SUPPLY.

THE Coal Strike, the Smoke Abatement Exhibition, and the recent and ever-increasing developments in the Diesel and the ordinary gas engine in large units, have combined to bring to the notice of manufacturers and power users the extreme importance of the efficient use of fuel in its many forms.

Mr. Bennis has recently indicated in our columns, that with but few exceptions, chemical manufacturers are extremely wasteful of coal. Mr. Kershaw has also mentioned a case of a large user in which the employment of a chemist so reduced this waste, that a saving of £25,000 per annum was recorded.

Increasing attention is being paid to the use of oil, in the form of a spray under the boiler. In the Diesel type of oil-gas engine (which dispenses with a carburettor and ignition apparatus) a similar position is observed, in view of the increasing use these engines are being put to, in units of 1,000 h.p. and upwards. It is suggested that even the battleships of 1920 will be propelled by this type of engine.

There are certain factors which seem to indicate that in all probability the gas engine will ultimately be used on land, and the oil engine chiefly reserved for marine work. This also seems a reasonable conclusion, when the huge interest involved in the coal industry of this country is remembered, and the additional freight cost of the raw material in the latter case is considered. It must be remembered in this connection that the use of the gas engine, working with "poor gas," is constantly utilising new and inferior qualities of fuel.

The chemical manufacturer has special conditions to meet. He will always be faced with the fact that he has to raise large volumes of steam under pressure, and this may materially modify the general plan which may be adopted.

This position may be solved by partly burning the gas (after removing the by-products) under the furnace for steam production, and generating the power required in gas engines. The first cost of installation is unfortunately high, but in view of recent experience in actual working, this is not so important a factor as it was a few years ago. A certain knowledge of the maximum size available for the unit has also led to a more satisfactory condition of affairs.

When it is remembered that coal requires 8—10 times the number of stokers as compared with oil fuel, it is realised that the actual cost of the raw material is not the only one to be considered, especially in the case of marine engineering.

The question of "white coal" does not enter very largely into our calculations in this country as it does in Norway or Italy, and even in that case the use of such power is more or less restricted to the production of electro-chemical products, such as nitric acid, carbide or cyanamide.

It would seem that future progress will probably be influenced by the use of the gas engine working in large units with the recovery of the nitrogen present in the coal, or lignite. Certain recent developments, as in the Humphrey pump, will also be remembered. In their way, these may have far-reaching results in hastening the economic use of "poor gas" in industry.

The more effective use of coal is also receiving increasing attention. In the case of the Bettington boiler, where the fuel is atomised and blown into the fire-grate in that form, results on a commercial scale are being obtained. An efficiency of 75%—80% being claimed with very inferior fuel.

The present position is one of great interest to the chemical engineer, and he is taking a considerable part in the development on the lines indicated. The problem is at least as important as that of the relative value of mechanical or electrical drive for machinery in factory or workshop, and is in fact closely connected with it.

It is impossible at the present juncture to indicate from the data available the future of mining coal by actual distillation in the seams as recently proposed by Sir W. Ramsay.

Progress.

Recent developments have cast a shadow over present social conditions, and given rise to speculation as to the future.

The balance of power has been disturbed and the country has been living under conditions which temporarily threatened to throw out of gear the central machinery of industry. A section of the community which deals with the supply of a universally required raw material of modern industry has gained abnormal power by withholding supply, and has used this as a lever when dealing with a sectional dispute.

Since the time when Science substituted the experimental for the empirical method, entirely new conditions of living have come into existence. Under the new *régime*, invention has followed invention. Motor cars, flying machines, phonographs, telephones, wireless telegraphy, and a host of other inventions and discoveries have brought to the notice of the manual worker in a direct and emphatic manner the outward signs of this silent revolution. He has pictured a promised land, to which those who have the power of purchase alone seem to secure the entry. It is a world to which he has seemingly remained outside, both in its inception, and to an extent in its fruition.

The manual worker has gained the idea that he is looking through the wrong end of the telescope, and that Science has by some process become the handmaid of the rich. This point cannot be argued here, but it is obviously an erroneous one. While taking an inconsiderable part in the development of this era, he has shared in the results to a surprising degree.

It may be that the present position is largely due to the fact that Science has for want of a sufficient number of its followers, or for some other reason, confined her attention to the extension of her experimental domain.

It has thus happened that the control of general affairs by legislation has been almost entirely left to those who have had a classical, or business training. This is probably a fundamental error, which it may be necessary at some future time to correct.

Politicians trained to certain ideas, which have not been those which have secured the advance recorded, have legislated for, or against, conditions which have been brought into existence by others, working with different thoughts and different aims. A prominent exception (which may be cited as showing the effect of the application of scientific methods) is that of general health, where legislation based on the advice of medical science has practically halved the death rate, and greatly improved general health conditions.

The present state of unrest may be partly traced to some such cause as that indicated. The politician has been legislating on lines which are not one with those forces which have moulded actual progress. Thus there has been no direct connection between the spoken words and actions of the politician and the causes underlying the great changes which have been fraught with such moment to all.

If this argument is correct, the remedy is with the scientist. By organisation, or otherwise, the relation between actual progress and legislation must be correlated. It must be seen that the legislators of the future are partly drawn from those who have a personal knowledge of the real causes of progress, which must determine the path which is to be walked by future generations.

The present position secures a happy hunting ground for the individual who, to mend matters, would destroy the social fabric. This is a suggestion which could hardly have received consideration if there was any general belief that legislation was determined on satisfactory lines.

The absence of a definite lead from those who have been primarily responsible for progress has opened the way to unrestricted legislation of an uncertain nature. Politicians of a certain class have procured a position which should never be occupied by those who have not had a training which renders them responsive to the actual conditions of modern progress.

Thus progress is hampered, and the floodgates of political venom remain open. The latter must be shut by methods, in which general confidence can be placed, and the sooner this fact is recognised the better it will be for the cause of real progress. This point is one of particular importance at the moment, when University representation is seemingly to have no place in an Irish Parliament.

Arsenic Compounds.

Further particulars are to hand concerning the work done by von Wassermann and Ehrlich, to which we referred a few months ago. It was suggested at that time that the modification of the toxic properties of the eosine compound was not beyond the powers of the chemist, and it would seem from recent information that this is the direction which is being pursued. The experiments are still confined to the lower animals, and it is stated that the results are of such a nature that the compound must be materially modified before it can be administered to human beings.

A much needed improvement is also announced by Prof. Ehrlich in the compound known as "606." From what we hear this is a necessary condition to its extended use by the medical profession. As an indication of the thoroughness of the tests now made it has been stated that positive evidence from 10,000 cases will be required before this new modification will be put on the market. The fact that this further step has been achieved is an indication that a similar one may in time be announced in the case of the eosine compound as used in the cancer experiments, and that every confidence may be placed in the pioneer work being done by these and other German investigators in the development of this new branch of chemico-therapeutics.

There can be no doubt but that investigations are being carried out on similar lines in this country, and that before long we shall hear of further progress

THE ESSENTIAL CONSTITUENTS IN FOOD.

By E. FRANKLAND ARMSTRONG, D.Sc., Ph.D., A.C.G.I.

It has long been recognised that carbohydrate, fat and protein, together with minute amounts of certain mineral salts, are the essential constituents of food, and various standards have been drawn up as representing the minimum requirements of the healthy individual. Proteins, which act primarily as tissue formers, have been regarded as of chief importance; but the customary method of estimating them in a food material, namely, the multiplication of the nitrogen present by an arbitrary factor, is to say the least an unscientific procedure. Not only does it include all nitrogenous matter as protein, it also classes all proteins as of equivalent nutritive value.

The investigation of the degradation products of proteins, which has been so marked a feature of research in this field during the last few years, has shown that although grossly similar the various proteins differ very considerably in detail. The various amino-acids, of which all proteins are constituted, are present in very different proportions in proteins of different origin, and some of them are altogether absent from a particular protein. The accepted view is that every one of the units at present known is of importance in nutrition: obviously a diet composed of one source of protein only will lead to the presence of an excess of particular amino-acids and to a deficiency of others perhaps equally important. The presence of every one of these units, at least in minimal quantity, is required to maintain health. It is by no means suggested that all or even the major part of the products of degradation of the protein are made use of by the body for the repair of the tissues. By far the larger proportion is undoubtedly used in other ways. Proteins can no longer be assumed to be equivalent in their food values, a conclusion which points to the value of a varied diet. Since animal and vegetable proteins differ with respect to their structural units, the use of both of them, as is our habit, is entirely rational. Less rational would appear to be the limitations imposed by a purely vegetable dietary. There is but little evidence as to the respective functions of the various amino-acids, though there is some indication that tyrosine and tryptophane are of special value; gelatine, in which both these amino-acids are absent, being generally regarded as of low food value. Hopkins and Willcock (*J. Physiol.*, 1906, *35*, 83) have shown that young mice fed exclusively with zein, the protein of maize, soon died. When tryptophane, a unit which is absent from zein, was added to the diet, life was greatly prolonged.

The natural step in endeavouring to elucidate the precise effects of the several constituents of food was to make use of pure food substances, isolated or purified by chemical means, instead of the mixtures constituting ordinary food material. The adoption of this line of research has been attended with somewhat unexpected results, involving the consideration of an altogether new factor in nutrition. The subject has also received consideration in connection with diseases resulting from a monotony of diet, such as scurvy or beri-beri. It is the purpose of this note to call attention to these new aspects: though much of the evidence is still of a contradictory and incomplete nature.

It has been frequently found that animals (rats or mice) are unable to exist on the "chemical food" alone. The most complete investigation of this character is that undertaken by Prof. Hopkins (as yet unpublished, compare *Annual Reports Chem. Soc.*, 1912, 235). He administered to rats an unlimited artificial milk diet, containing model proportions of pure proteins, fat, carbohydrates and salts, but found invariably that, though they partook freely of it, the animals soon died. The addition of very small traces of various fresh extracts of animal or vegetable materials, milk, etc., although adding practically nothing to the amount of nutrient material as ordinarily measured, had a remarkable effect in enabling the animals to utilise fully the artificial food.

The inference is that fresh foods contain, in the minutest proportions, certain essential constituents which enable the other materials present to be utilised. Prof. Hopkins is at present engaged in establishing their nature.

Although other observers support Hopkins, Osborne and Mendel claim to have been more successful in keeping animals alive on a purely artificial diet.

Abderhalden (*Zeitsch. physiol. Chem.*, 1912, *77*, 22), in his last paper, describes successful experiments in which, for the first time, dogs have been fed on a diet entirely composed of cleavage products of proteins, fats and carbohydrates. Since it is only a question of money to prepare all these cleavage products from the elements by synthetical operations, Abderhalden infers that the problem of maintaining life on a purely synthetic diet has been solved, and that the animal is able to build up all its cell constituents from the simplest materials. The experiments were made with dogs, hardy street mongrels for choice: success depended on the existence of a friendly feeling between the dog and the person who fed it, no one else having anything to do with the dog. Such dogs were fed in three cases for 74 days, and in one case for 48 days, the artificial diet consisting of the cleavage products of ox flesh or casein, a mixture of glycerine and fatty acids and glucose.

Complementary to Hopkins' experiments are those made by Stepp (*Zeitsch. f. Biologie,* 1911, *57,* 135), in which mice were fed on a diet made by combining rice with new milk. The mixture was dried and extracted exhaustively with ether and alcohol to remove the fats and other substances collectively spoken of as lipoids. Whereas the original dried food enabled the mice to thrive, they soon died when fed with the extracted food. The fatal result could be prevented by the addition of the evaporated extract, showing that this contained an essential constituent of the food. In subsequent experiments the possible ether-alcohol soluble substances were added to the extracted food, one at a time. Butter and other fats, mineral salts, lipoid substances such as cholesterol or lecithin, were equally without effect. On the other hand, the dried ether-alcohol extract of new milk restored the full value to the food, though a similar extract made from boiled milk was of no value. Stepp infers that the presence of lipoids is essential for food to be of value, thereby ignoring the possible presence of other substances in his ether-alcohol extract.

The association of beri-beri with the consumption of polished rice, that is rice freed from pericarp and husk, is now generally admitted, and it has been found that fowls or pigeons fed on polished rice develop an analogous form of polyneuritis, whereas, when fed on unpolished rice, they remain healthy. Fraser and Stanton, in a publication from the Institute for Medical Research in the Federated Malay States, in 1911, show that when the polishings from rice are added to polished rice and the mixture is fed to fowls they remain healthy. Obviously the rice polishings contain a substance of prime physiological importance. A systematic attempt was made by these authors to isolate this essential constituent, and a fraction soluble in 90% acidified alcohol, amounting to about 1% of the original grains, was obtained, which contained the protective substance and included the alcohol soluble proteins of rice with compounds of calcium, magnesium and phosphorus.

Funk (*J. Physiol.,* 1911, *43,* 395) has taken the investigation a step further in showing that the protective substance is an organic base completely precipitated by phosphotungstic acid, which is at first precipitated together with chlorine and subsequently purified. A crystalline nitrate was prepared from the base and analysed, but the figures are regarded only as provisional. At each stage of the purification the protective substance was proved to be still present by administering small doses of the product to pigeons suffering from the polyneuritis; in positive cases they were cured within twelve hours.

It is of interest that Funk's final preparations contained no phosphorus, although the estimation of the total phosphorus in rice gives the best indication whether the grain is suitable for food. This is due to the fact that the polishings are relatively rich in phosphorus. Much emphasis has of late been laid on the food value of phosphorus, especially of organic phosphates, both in connection with the use of wholemeal bread and with other much advertised articles. It is well to emphasise the fact that as yet we have no experimental evidence in favour of this view, and Funk's experience certainly lends it no support.

Particularly interesting is the work done by Axel Holst, of Christiania, with Frölich and Fürst, which appears to have escaped the notice of most of the English workers on beri-beri. It originated from a study of the causes and prevention of scurvy on board sailing ships, where the diet is very monotonous in character, as every ingredient has either been dried or heated to make it keep for a long period: as a consequence scurvy is frequently experienced. It may be prevented in practice by the addition of fresh potatoes, apples or turnips to the food; but, apparently, once such vegetables have been dried their value is lost.

Experiments with rabbits, placed on a diet of bread and cabbage, proved that they did well, even when the cabbage was boiled for a short time at 100°; but after heating it at 110° the nutritive value was entirely destroyed, and the animals eventually died. Cabbage juice loses its value as an antiscorbutic when kept for some time sterile in closed vessels, or frozen, or when heated at 60°C.: its effect is evidently due to certain very easily decomposed substances. Lemon-juice is another weak antiscorbutic, but it is of more permanent character: it will keep for some time and tolerates heating at 100°.

Attention is called also by Holst to the tendency to increase of an allied disease—infantile scurvy—caused by prolonged use of prepared cereal infants' foods or milk foods, or milk which had been heated for a long time at a high temperature to sterilise it completely. In all such cases fresh unboiled milk has great healing powers, and it is assumed to contain certain thermolabile substances, possibly allied to enzymes, which are indispensable. In confirmation of the above, rabbits were shown to die on a diet of milk alone, whether fresh or boiled. On new milk and oats they throve, but boiled milk and oats did not keep them alive.

The usual criticism applied to experiments with animals, in which one form of food alone is administered, is that certain constituents of a complete diet—for example, certain amino acids—are probably absent. Holst and his assistants show that rabbits fed on a diet made up of a dozen or more different substances, together with water, died of scurvy, if the food materials had all been thoroughly dried at 37°C., or in a vacuum previous to the experiment. The addition of ordinary dry oats to such a diet did not help the animals, but when fresh germinating oats were substituted the animals were able to thrive and make full use of the rest of the diet. Drying the germinating oats at 37° destroyed their curative properties, but these were restored when the oats were moistened again and allowed to germinate further. The same results were obtained with germinating peas, lentils, etc.

These researches do not carry us as far as those of Fraser and Stanton or Funk, in throwing light on the chemical nature of these remarkable constituents of foods, but they afford much additional evidence of their great importance in maintaining health.

It is unwise at present, pending further experimental research, to discuss the bearing of the results cited. Their novelty will assure that they receive full investigation at the hands of chemists and physiologists.

THE PRESENT DEVELOPMENT OF METALLOGRAPHY.

By WALTER ROSENHAIN, B.A., D.Sc.

THE pioneer work of Henry Clifton Sorby, in 1864, first showed that the inner structure of metals could be studied by means of the microscope, and the young science which has since grown up under the name of "Metallography" has already brought to light results of far-reaching importance, and holds out promise of further results of yet greater magnitude. For, while no doubt the fundamental properties of the molecules, atoms or even electrons of the metallic elements are essential and governing factors for many of the properties of metals, yet it has been shown that certain of these properties are related not so much to the molecular or atomic constitution as to the particular form and arrangement which the molecules will assume under given conditions, and it is with the detailed analysis of these proximate conditions that Metallography is concerned. In one sense, therefore, it constitutes a form of "rational analysis" of metals and alloys, and plays for them the same part which petrography plays for the study of rocks. But the scope of metallography is much wider than this, since it deals with the whole range of the physical chemistry of metallic alloys on the one hand and with the correlation of constitution, structure and composition with the mechanical properties of metallic bodies on the other hand. In this wider sense the new science is rapidly stepping beyond the limits of "Metallography," as formerly defined, and it would almost seem that it would be more appropriate to describe the new science as "Physical Metallurgy," as covering the whole range of knowledge dealing with metals after they have been separated from their ores. The science of metallurgy in general would thus be divided into two great sections, viz., what might be termed "chemical" or "process" metallurgy, dealing with the production of metals from their ores, and "physical metallurgy," dealing with the constitution, properties and treatment of metals after they have been obtained in the metallic condition. Such a division is of necessity a rough one, since such refining processes as those used in the conversion of pig-iron into steel might well belong to both classes, while the study of the physical chemistry and constitution of slags and metalloid bodies, such as mattes, etc., opens up one of the most promising fields for what are usually regarded as purely metallographic methods.

That this science of physical metallurgy is receiving a constantly increasing amount of attention, and that its wide-spread importance is finding a larger measure of recognition, is beyond doubt at the present time. Evidence of this tendency is to be found in every direction. Thus the installation of metallographic laboratories in all the larger manufacturing establishments which deal with metals and alloys, either as producers or as extensive users, has already been carried out to a very large extent, and those firms who have not yet taken such a step are finding themselves in difficulties accordingly. Even in the advertising literature, references to this science and its results are now often to be found, and there are very many industrial operations which are regularly controlled by its indications. Then, again, those who are concerned with the testing of materials are relying to an ever-increasing extent upon metallographic methods—not as superseding, but as a powerful aid to the older methods of purely mechanical testing. In the Government Departments this recognition of the value of "physical metallurgy" is now definite and extensive; in cases of failure investigated by the Board of Trade, for example, metallographic science has been found to afford essential assistance in the solution of difficult problems, and both Departmental Papers and reports of official enquiries are to be found in which metallographic evidence plays a leading part.

In another aspect, the increasing importance of physical metallurgy may be traced in the publications of our scientific and technical institutions. The publications of the Royal Society of the Iron and Steel Institute and of the Institution of Mechanical Engineers show an increasing number of important papers dealing with subjects well within the scope of physical metallurgy, and particularly with the results of microscopic research on metals and alloys. Perhaps the most striking indication of this kind is to be found in the history of the comparatively newly-formed Institute of Metals. The rapid rise of this young Institute during the four years of its existence is well known, but it is a striking fact to find, on looking into its Journal, how large a proportion of its energy this institution has derived from, and devoted to, this particular branch of applied science—and this fact, coupled with the prosperity of the Institute, serves to show how much this energetic pursuit of physical metallurgy in all its branches appeals to the interest of those who—as manufacturers or users of metals and alloys—constitute the growing membership of the Institute. Another symptom of the same kind is to be found in the recent opening of the new "Wernher Building" for metallurgical research, at the National Physical Laboratory. The metallurgical research, for which this building has been designed and erected, is entirely of the nature of "physical metallurgy," in which the microscopic and pyrometric study of metals plays a prominent part. So far as the writer is aware, this building constitutes the only laboratory in the world which is entirely devoted to the science of physical metallurgy; but it is probably safe to say that this example is likely to be quickly followed elsewhere. In Germany there are, however, already several actual University professorships of metallography and this example has yet to be followed in England.

With this splendid story of strong and energetic development before us, we may well ask what are the precise aims and objects of this newly-developed science, and to what ultimate results may we expect it to lead us? The answers to be offered to such questions would necessarily vary according to the individual tastes and aims of the particular devotee of the science to whom the questions were put, but a few broad outlines may perhaps be sketched with safety. Thus there is no doubt that the immediate aim pursued by most of the investigators working at this subject is that of the completion of our knowledge of the constitution of metallic alloys. The stage which has been reached at the present time is that a preliminary survey of the binary alloys has been completed, and that more detailed and accurate studies of certain groups of special interest are being carried out by those who have at their disposal the requisite delicate apparatus. The results of such investigations are represented in "equilibrium diagrams," and first approximations to these have in many cases been obtained by a large group of students under the direction of Professor Tammann, at Göttingen. Now, valuable and interesting as their diagrams undoubtedly are, they were prepared primarily for the purpose of ascertaining the existence or otherwise of definite intermetallic compounds, and from the present standpoint of metallography they are inadequate and in many cases far from sufficiently accurate. Thus, recently, the diagrams of the copper-zinc, the lead-tin and the aluminium-zinc alloys have undergone revision in important respects; but, unfortunately, all these revisions appear to indicate that the correct diagrams are far more complex and difficult to interpret in the light of the "Phase Rule" than the first rough approximations. Indeed, Guertler has gone so far as to say that it was fortunate that the earlier investigators were not armed with the delicate apparatus now employed, as the complexity of the results might have deterred them from pursuing the subject. None the less, these complexities and difficulties are being steadily grappled with and overcome, and when the realm of binary alloys is satisfactorily conquered, the vastly larger field of ternary alloys will be more briskly attacked than has yet been done. But if it is borne in mind that where fifty observations would suffice for a binary series of alloys, 1,250 would be required for an equally complete study of a ternary system, the vastly increased laboriousness of these wider researches becomes apparent. Yet, ultimately, the ternary alloys must be conquered, and even alloys of four and five metals will have to be systematically studied.

While the pursuit of the accurate knowledge of the equilibrium conditions of alloys constitutes one of the fundamental tasks of the science, physical metallurgy is equally concerned with the departures from equilibrium which arise from thermal and mechanical causes. The effects of rapid and slow cooling, either from fusion or from lower temperatures, the whole range of such phenomena as hardening and tempering, annealing and quenching, are all subjects for exhaustive study. Much has already been attained in this direction, but it is merely the beginning of that knowledge which ultimately should reveal to us the true inner mechanism which governs the physical behaviour of metals. In this connection it is interesting to remember that pure metals are probably the simplest forms of solid matter with which it is possible to deal, so that while we may pursue our studies of metals from the metallurgical standpoint, it is probable that discoveries as to these inner mechanisms in metals will be of material help in building up our general knowledge of matter, and particularly of the solid crystalline state.

The results to be anticipated from the further fruitful development of metallography, or rather of the wider science of "physical metallurgy," must therefore be looked for in many varied directions. There are results of a purely scientific kind, possibly the most important of all in furthering that deeper insight into nature which is fundamental to all material progress; then there are the direct practical results—in the detailed study of the metallic materials available for technical purposes, and in the discovery not only of the best composition of an alloy for each specific purpose, but also the determination of the best mode of treatment—chemical, thermal and mechanical—to which each of these materials should be subjected. In this direction the "trial and error" methods of the "practical man" have already carried us astonishingly far, but scientific guidance based upon a systematic knowledge of metals and alloys will carry us much further yet. Finally, and of at least equal importance with the two directions of progress already indicated, the pursuit of the methods of investigation which have grouped themselves around metallography is steadily leading us towards a deeper insight into the inner mechanism of structure and constitution which makes it possible for our materials of engineering to meet the rapidly increasing demands which are made upon their powers of resistance. We are learning to know something of those sources of uncertainty which are familiar in practice—uncertainties which sometimes lead to serious failures in spite of careful design. More serious still is the effect of these uncertainties on engineering design, which, in the form of large "factors of safety," they hamper with huge accumulations of dead weight. The deeper knowledge of our metallic materials will steadily tend to lessen all such uncertainties.

These are but the general order of results which are already more or less in sight, though not yet by any means attained. As the science progresses, however, fresh vistas are sure to open, for no man has yet proved bold enough successfully to anticipate the developments which the progress of any new science has brought in its train. With these great problems before it, and with the achievements towards their solution already to its credit, "metallography," or "physical metallurgy," may surely claim an equal place beside the older branches of chemical and physical science.

THE CATALYTIC ACTION OF METALLIC OXIDES ON PRIMARY ALCOHOLS.

By ARTHUR CLAYTON, D.Sc (Lond.), A.R.C.S.

OF the innumerable problems confronting the organic chemist, there are perhaps none more fascinating or elusive than those presented by the phenomena of catalysis. It is therefore not surprising that the action of catalysts on organic compounds should have attracted a considerable amount of attention during recent years, and researches in this direction have been rewarded by discoveries of the greatest interest and importance.

Some ten years ago Grigorieff showed that when the vapour of ethyl alcohol is passed over aluminium oxide, heated at about 300°C., dehydration takes place with the formation of ethylene and water; and at the same time, although to a lesser extent, aldehyde is produced by a process of dehydrogenisation. The aluminium oxide appeared to be unaltered during these changes, and evidently played the important and mysterious part of a catalyst.

At this stage the investigation was taken up by Sabatier and Maihle, who made an exhaustive examination of the action of numerous metallic oxides on primary alcohols at temperatures not higher than 400°C. It was found that whilst some oxides were reduced to the metal or to a lower oxide under these conditions, others were apparently unchanged, and in almost every instance oxides of the latter class caused the catalytic decomposition of the alcohol. This decomposition, as indicated by the work of Grigorieff, was in general found to proceed in two directions:

(1) Dehydration, leading to the formation of water and an ethylene or ether.
(2) Dehydrogenisation, with the production of an aldehyde and hydrogen.

The predominance of either of these actions is determined by the nature of the oxide employed, as may be seen from the subjoined table, in which is shown the action of various metallic oxides on the vapour of ethyl alcohol at a temperature of 340—350°C.

Catalyst (Prepared at 350°C.)	Volume of Gas disengaged per Minute (in c.c.)	Percentage Composition of the Gas.	
		Ethylene	Hydrogen
ThO_2	31	100	Traces
Al_2O_3	21	98·5	1·5
W_2O_5	57	98·5	1·5
Cr_2O_3	4·2	91	9
SiO_2	0·9	84	16
TiO_2	7	63	37
GlO	1·0	45	55
ZrO_2	1·0	45	55
UO_2	14	24	76
M_2O_5	5	23	77
V_2O_3	14	9	91
ZnO	6	5	95
MnO	3·5	0	100
MgO	Traces	0	100

The first column contains some of the oxides employed, and in the second is shown the volume of the gas disengaged when the alcohol was supplied at a definite rate. Since this rate of supply was the same in each case, the figures in this column serve to indicate the comparative activities of the oxides in promoting the catalytic decomposition of the primary alcohols. In the third and fourth columns is shown the percentage composition of the gas evolved in each case; thus it is seen that whilst thorium oxide yields only ethylene and water, the oxides of magnesium and manganese act in such a manner that hydrogen and acetaldehyde are the sole products. Between these extreme cases are a number of oxides which cause simultaneous dehydration and dehydrogenisation in varying degrees. It should also be noted that Senderens has found that if the vapour of ethyl alcohol is passed over aluminium oxide heated at 240—260°C., ether and water are alone produced. This discovery has led to the proposal to use the method in the manufacture of ether, and it is possible that further developments may render the process a commercial success.

There appears to be no definite hypothesis to account for the catalytic dehydrogenisation induced by metallic oxides, although the view has been taken that the action may be due to the temporary fixation of the hydrogen, or perhaps of the aldehyde.

A more complete explanation, however, has been proposed to account for the process of dehydration; thus the catalytic influence exercised by the oxides of aluminium and thorium is considered by Sabatier and Maihle to be due to the chemical changes indicated in the following equations, where ethyl alcohol is taken as an example:—

(1) $Al_2O_3 + C_2H_5OH = 2AlO(OH) + C_2H_4$

(2) $ThO_2 + 2C_2H_5OH = ThO(OC_2H_5)_2 + H_2O$

$ThO(OC_2H_5)_2 = C_2H_4 + ThO(OH)_2$

In each case the hydroxide formed is unstable at the temperature of the experiment, and breaks down with the regeneration of the oxide, which is thus able to cause hydration to an unlimited extent.

It was found by Sabatier and Maihle to be of the greatest importance that the catalyst should be prepared at a fairly low temperature; thus aluminium oxide prepared by heating the hydroxide to 400°C. is very active, whilst if strongly heated, or in the crystalline form, the substance is almost incapable of exerting catalytic influence. This peculiarity is doubtless due to the fact that all catalytic actions take place at the surface of the catalyst, and the greatest surface is exposed when the oxide is in the most finely divided condition.

Although chemists are still far from understanding the exact nature of catalytic action, investigations, such as those of Sabatier and Maihle, must have a powerful tendency towards the perfect comprehension of this remarkable type of chemical change. With such important examples before us as those which exist in the world of inorganic chemistry, there is every hope that the further efforts of organic chemists will bring to light methods by which catalysts may be further employed, not only in the laboratory, but also in the wider fields of commercial enterprise.

NOTES OF MEETINGS, &c.

THE CHEMICAL SOCIETY.

May 2nd and 16th, at 8.30 p.m.—Ordinary Meetings.

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SOCIETY OF PUBLIC ANALYSTS.

May 1st, 8 p.m.—Ordinary Meeting.

The following papers will be read:—"The Analysis of Lithopone," by W. L. Austin and Charles A. Keane, Ph.D., F.I.C.; "The Effect of Calcium on the Ammonium Molybdate Lead Assay," by C. O. Bannister and W. McNamara; "The Constituents of Oil of Savin," by J. Watson Agnew, F.I.C., and Robin B. Croad; "The Detection of Heavy Petroleum in Paints and Vegetable Oils," by W. B. Pollard, B.A.

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SOCIETY OF DYERS AND COLOURISTS.

LONDON SECTION:—Meeting at Leathersellers' College, May 7th. "The Dyeing of Furs," by M. C. Lamb, F.C.S.

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SOCIETY OF CHEMICAL INDUSTRY.

May 6th, 8 p.m.—"A Method for the Comparison of Coking Properties of Coals," by R. Lessing.

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ROYAL SOCIETY OF ARTS.

Monday, May 6th, 8 p.m.—(Howard Lecture.) Captain H. R. Sankey, R.E., M.Inst.C.E., "Heavy Oil Engines." (Lecture II.)

Monday, May 13th, 8 p.m.—(Howard Lecture.) Captain H. R. Sankey, R.E., M.Inst.C.E., "Heavy Oil Engines." (Lecture III.)

Wednesday, May 15th, 8 p.m.—(Ordinary Meeting.) Ernest Kilburn Scott, Assoc.M.Inst.C.E., M.I.E.E., "The Manufacture of Nitrates from the Atmosphere." Sir William Ramsay, K.C.B., Ph.D., Sc.D., F.R.S., will preside.

CHEMICAL INDUSTRY and ENGINEERING EXHIBITION.

Mr. F. W. Bridges has decided to hold a second Exhibition at the Agricultural Hall during June, 1913. Mr. W. F. Read, who acted as Chairman of the Hon. Advisory Council on the last occasion, has been elected President of the forthcoming Exhibition, and Mr. C. T. Tyrer, Chairman of the Hon. Advisory Council.

The scope of the Exhibition has been enlarged to definitely include Chemical Industries. It will be remembered that the sectional committees of last year dealt with the following exhibits:—

> Colouring Matters and Dye Stuffs; Preparing, Bleaching, Dyeing, Printing and Finishing Textiles; Yarns and Fibres; Colouring Wood, Paper and Leather; Pigments and Paints; Resins and Varnishes; India-rubber, Tanning, Leather, Glue, Size, Bone, Ivory and Substitutes; Colouring of Leather; Celluloid; Sugar, Starch, Gum, Brewing, Wines and Spirits, etc.; Foods, Sanitation; Water Purification and Disinfectants; Acids, Alkalies, Salts and Non-Metallic Elements; Glass, Pottery and Enamels; Building Materials, Clays, Mortars and Cements, and Refractory Materials generally; Electro-Chemistry, Manures, Fine Chemicals, Alkaloids, Essences and Extracts; Fats, Fatty Oils, Waxes, and Soap Manufacture and Blacking; Fuel, Gas and Light; Destructive Distillation; Tar Products and Petroleum; Metallurgy and Mining; Electro-Metallurgy, Explosives, Matches, etc.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

RUBBER AND ITS CULTIVATION.

By CLAYTON BEADLE and HENRY P. STEVENS, M.A., PH.D., F.I.C.

(Continued from page 120.)

As for the resins, we are completely in the dark. We do not know whether the resin is in the form of separate globules, the remaining globules containing caoutchouc only, or whether it is intimately associated with the caoutchouc, each globule containing both resin and caoutchouc. All we know is that on coagulation the resins separate out along with the caoutchouc.

The coagulum retains a trace of the acid substance used for coagulation, and the amount found in the raw rubber will depend on the method adopted for the purification and treatment of the fresh coagulum. If the rubber be "creped" so that it undergoes a thorough washing with cold water, the residual acid seldom exceeds ·1% (reckoned as acetic), even where considerable excess of acid has been used. It is generally well under ·05%, and may be so small that ordinary methods fail to detect acidity at all.

If the rubber is not "creped" but merely squeezed and surface washed (sheet and biscuit) the percentage of acid retained often exceeds ·1%, and with smoked rubbers may exceed ·2% owing to the absorption in the smoke-drying process. This also applies to fine Para, which shows, on an average, about ·15%. The fact that acid is generally retained to some extent by the rubber even when thoroughly washed (crepe) makes one cautious in the choice of acids as coagulants. This especially applies to mineral acids, although these do not seem to be absorbed (or adsorbed?) to a larger extent than vegetable acids.

The smoking, or to speak accurately, the smoke drying of rubber presents another unsolved problem. The process was at first regarded as a fad started on rubber plantations to imitate the Brazilian coagulation process. The latter is an actual case of smoke coagulation, but in the former the rubber is coagulated in the ordinary fashion with acetic acid, and then hung in smoke to dry, so that there is no real parallelism between the two operations. As, however, smoke drying gave the rubber a smoky smell, though different from the "kippery" odour of fine Para, and as everyone at the time was talking about smoked Amazon rubber and attributing quality to smoking, this new "smoked" rubber from the East found a good market. The demand for this grade and the price paid has fluctuated from time to time as compared with the pale washed crepe, but the prices of both have been more or less on a par for the last few months. Yet all tests point to the superiority of the smoked rubber as compared with the pale crepe. It is only necessary to refer to the awards made on more than one hundred specimens of variously prepared rubbers and based on tests carried out by independent manufacturing firms at the recent London Rubber Exhibition. We are, however, quite at a loss to explain the action of the smoke. Is it chemical or physical, or both? The old theory was summed up in the indefinite term "creosote," and attempts were made two or three years ago to send home rubber, wet and impregnated with "pure creosote." This large scale experiment was not a success, and although it created a good deal of interest at the time, nothing further has been done in that direction. We were next told that the acetic acid was the effective ingredient, and it certainly is, so far as concerns coagulation of the thin layers which go to form a ball of fine Para. The latest theory puts forward carbon dioxide as the essential coagulant in the preparation of smoked rubbers, and a new method of coagulation has been advertised in which the gas is used, but no explanation of its action is forthcoming.

These and similar facts lead us to conclude that the differences in behaviour of different raw rubbers are connected with the protein and resinous constituents. Further, the structure and possibly also the composition of the caoutchouc complex may play a part. The natural caoutchouc may consist of isomeric substances such as are formed in the production of the synthetic substance, and may also contain hanologous caoutchoucs in which the molecular proportions of carbon and hydrogen approximate to the C_5H_8 formula. The proportion of carbon to hydrogen in caoutchouc is not capable of determination with great accuracy, as we have no means of efficiently purifying the hydrocarbon. By fractional precipitation we may remove many of the impurities, but a small proportion of oxygen always remains.

Only a year or two back fine Para in the raw state was fetching the same price as the best plantation rubber, in spite of the difference in yield of clean dry rubber. To-day, for the first time in history, plantation so-called "first latex" is at a premium of about one shilling per pound over fine hard Para, thus compensating for the 15% to 20% "loss on washing" referred to above. Plantation rubber has only slowly crept up to its present market valuation. Looking back, it is difficult for us to refrain from referring to the numerous statements we have made at one time or another, based on technical experience and research, pointing to the approximate equality of plantation and fine hard Para. We were always met with the argument that it could not be so or manufacturers would pay more for the plantation variety. A comparison of market valuations with intrinsic merits gave rise at the time to some interesting suggestions by those who perhaps did not sufficiently realise the numerous factors governing the demand for any particular article. The suggestion was made that the plantation *Hevea* trees were derived from seeds collected in regions where "fine hard" is not produced, and that the tree was a different variety of *Hevea* from that yielding fine Para rubber. While on the one hand this statement has been contradicted by Wyckham, who collected the seed, it is more than likely that different varieties of *Hevea* go to the production of fine Para. We have information from a native source that both *Hevea Braziliensis* and *Hevea Guyanensis* are tapped for the production of Brazilian Para rubber, and the latter source is generally recognised as yielding an inferior quality of rubber. This may account for the great variation in strength (up to 50%) shown by different parcels of this rubber.

When working with a colloidal state of matter such as caoutchouc, we are almost entirely dependent on physical properties for a measurement of quality. Our difficulties are not diminished by the fact that caoutchouc is not used in the form in which it is produced, but after passing through the process of vulcanisation. This profoundly modifies its physical properties and behaviour. Slight changes in the vulcanisation conditions, which may be shortly termed the "cure," alter the physical properties in a disproportionate degree, so that it would appear desirable at the start to fix on standard conditions for vulcanising—that is to say, a standard cure. Unfortunately, this is found to be impossible. There is no fixed cure equally suitable to all varieties of rubber, even if these be restricted to rubbers of the same botanical origin. There is for every specimen of rubber a narrow limit of conditions, which comprise a satisfactory cure. Outside this limit, whether the conditions be altered so as to increase or decrease the time, temperature, proportion of sulphur, sulphur carriers, etc., the result is to produce a vulcanised rubber which is unstable and loses in quality on keeping. It follows from these considerations that a single cure will not suffice when examining a sample of raw rubber of unknown origin. A number of experimental cures must be made, each of which is subjected to certain physical tests, and the samples are then filed away for future reference. At the end of a twelve-month they are re-examined and their state of preservation carefully noted. If any of the cures have been very wide of the mark, a rough hand test will be sufficient indication, the rubber becoming short and brittle. But to distinguish between those cures which more nearly approximate to the ideal for that particular rubber, it is necessary to retest the samples. A comparison of the figures so obtained, with those originally given by the same specimens, enables a thorough insight into the quality of the original raw rubber to be obtained. It would be obviously impracticable to wait so long for the results of a commercial test nor is it necessary; when once sufficient experience has been gained it is possible to estimate the cure for any grade with a fair approximation to accuracy.

Much difference of opinion exists as to the condition of the sulphur in vulcanised rubber. The old theory that a true chemical combination takes place has, in recent years, been largely supplanted by an adsorption theory. Much light has been thrown on the relationship by the recent work of Spence. By continued acetone extraction of a sample of rubber vulcanised in the usual manner it was found that the first portion of the so-called free sulphur came away readily, but further successive extractions removed less and less, while the remainder, the so-called combined sulphur, could not be removed at all. On plotting the amounts of sulphur extracted against the times of extraction, the form of adsorption curve was obtained. The sulphur in vulcanised rubber may therefore be ranged under three heads: (1) the free, (2) the adsorbed, and (3) the chemically combined. The proportion of sulphur adsorbed (2) is relatively small, and the greater part of this together with the actually free sulphur (1) represent what is commonly known as "free sulphur." The free sulphur, as usually understood, is determined by extraction for six to eight hours with acetone in a soxhlet. In more recent experiments, where an excessive amount of sulphur (13·14%) was used for vulcanisation, there was found to be a distinct break in the curve indicating the transition from the free sulphur (1) to the adsorbed (2).

These facts may be taken into consideration with certain chemical evidence. Thus, where vulcanised rubber is nitrated, the sulphur is not oxidised but passes quantitatively into the nitro product, or again, in the bromination of vulcanised rubber, the double linkages satisfied by sulphur are not available for the bromine. A thorough bromination yields a di-bromide of the C_5H_8 complex, and corresponding to this the formula for a rubber completely vulcanised with sulphur would be C_5H_8S or $C_{10}H_{16}S_2$, taking the molecule of caoutchouc as $C_{10}H_{16}$. As a final example, we may refer to the vulcanisation of regenerated or reclaimed rubber. In this commercial process the combined sulphur is not removed and the reclaimed rubber takes up a further proportion of sulphur in the process of vulcanisation in the same manner as raw rubber would. Moreover, the combined sulphur in vulcanised rubber is extremely difficult to remove, and the ordinary reagents, such as boiling alkalies, fail to have any effect upon it. Such behaviour is hardly conceivable in the case of adsorbed sulphur, but points rather to sulphur firmly held in chemical combination. Other constituents in the rubber may also react with sulphur in the process of vulcanisation, in particular the resins, and this matter is of considerable technical importance when dealing with low grade and very resinous rubbers. As pointed out above, the reaction of sulphur and caoutchouc is an additive one, consequently no sulphuretted hydrogen or gaseous compounds are produced during the vulcanisation.

On the other hand, resins react differently, and the gaseous products may cause porosity of the vulcanised rubber unless the precaution be taken of adding basic minerals to the mixing, such as magnesia, zinc oxide, and litharge. These basic minerals have also a very marked action on high class rubber mixings, in which the amount of resin does not exceed 2 to 3% on the rubber. The effect, as we have shown, is to increase the proportion of combined sulphur. At the same time, the strength of the product is increased, and although the limit of elongation is somewhat reduced the rubber retains its resiliency. The matter is, however, somewhat obscure, as inert minerals also increase the proportion of combined sulphur, although to a lesser extent, and, except in small proportions, reduce the limit of elongation. But, in this case, the quality of the product suffers and the rubber is hardened and comparatively lifeless.

PURIFICATION OF GLASGOW SEWAGE AND THE STATE OF THE LOWER CLYDE.

By S. Rideal, D.Sc., F.I.C.

The present remedial measures at Glasgow for about the most ancient problem of Applied Chemistry in the British Islands have led to a certain measure of success, and I have ventured to offer a few comments and criticisms which may conduce to a further advance. The upper Clyde, as we know, is one of the most beautiful of rivers, and near Lanark, at Corra Linn and Bonnington Linn, is exploited for the admiration of tourists, with limpid water and snowy spray of the waterfalls. But gradually and progressively the sewage of villages and industrial towns makes the water run turbid, and with a less content of dissolved oxygen, so that when it arrives at Glasgow it is already a polluted stream.

My mention of dissolved oxygen is prompted by the fact that it furnishes a most important index of the salubrity of rivers. The earliest recorded chemical requirement at Glasgow anticipated Dibdin's "fish test" by about 300 years, when the Scotch Privy Council penalised discharges "which were hurtful to the fishing," as at that time the lower Clyde was a fishing river. The great process of widening and deepening it later, to turn it into a canal for carrying ships, made Glasgow the richest city in Scotland, and its river decidedly the worst. In 1755, the Clyde at Glasgow was only 15 ins. deep at low water and 3 ft. 8 ins. at high water; in 1888, after the alterations, it was 15 ft. at low water and 26 ft. at high water. In the early commercial gain the sanitary aspect was forgotten, so that the lower Clyde became an open sewer, and reports say that it is little better than that now, when it is churned up by the steamboats, or when anyone wishes to land on the black mud banks, or when odours from the river are occasionally felt; and, of course, the main fault is the sewage of Glasgow.

The subject has just been discussed in connection with three papers at the Institution of Civil Engineers, the first by A. B. McDonald and Midgley Taylor, on the "Main Drainage of Glasgow," the second by Mr. Easton, on the Construction of the Works, and the third by Mr. Morton on their Mechanical Equipment and Pumping Arrangements. The first paper gives a historical account of the growth of the difficulty, and remarks that "the miles of wharfage and acres of docks that were the outcome of the unparalleled progress of the city became gradually the chief consideration of the community, which even went so far as to tolerate the great nuisance created by the ever-increasing foulness of the river caused by the discharge of domestic and industrial refuse."

A part of this accretion of foulness was stopped by modern sanitary regulations, but many projects were started for the conveyance of the sewage of Glasgow by tunnels or conduits to various points on the seashore, and there were several plans for the deodorisation. Finally, the local works at Dalmarnock, Shieldhall, and Dalmuir, were successively installed for different districts of the city. The sewage received at Dalmarnock is said to be of a complex and intractable character, consisting principally of industrial refuse, and carrying up to 1,000 grains per gallon of suspended solids. It is stated in the report that "the treatment of such sewage is a matter of no ordinary difficulty, and the proportion of the chemical ingredients used sometimes varies as often as 33 times during the day."

The process finally adopted therefore, is the expensive one of chemical precipitation by lime and sulphate of iron, with the production of a very large sludge, which is settled to half its bulk, pressed, dried, and ground, and then offered as "Globe Fertiliser Sewage Manure." We seem to be 50 years back in sewage treatment.

Naturally, there is "a complete withdrawal of suspended matter" and "an excellent effluent" from this point of view, and the analyses given show an elimination of about 50% of the dissolved organic matter; but the significant remark is made that "as the effluent (from Dalmarnock) has to be discharged into *non-tidal* waters the Sewage Committee are considering the expediency of installing a group of bacteria beds *for the further purification of the effluent*," while for the works lower down, Shieldhall and Dalmuir, it is concluded that "a degree of purification sufficiently good for the *tidal* waters of the river Clyde could be obtained by chemical precipitation alone." The published figures show that the Shieldhall works are the most expensive, presumably from the use of more chemicals, while the effluent has a very much lower purification than at the other stations. The distinction between "tidal" and "non-tidal" waters, founded on the position of the different works, should not here involve a less standard of purity for the former than for the latter. The upper station receives the first influx of fresh river water, the lower ones receive the wash of the tides.

The Clyde itself, from the printed analysis, is still robbed largely of its dissolved oxygen, and the deficit is increasing. The low water figures given for samples taken opposite Dalmuir, are, in c.c. per litre: June, 1910, 4·60; August, 1910, 3·67; September, 1910, 3·00; October, 1910, 2·86; November, 1910, 1·84; December, 1910, 5·93; January, 1911, 2·04; February, 1911, 1·80; March, 1911, 1·89; April, 1911, 0·76. The record unfortunately breaks off here, but at this rate of decrease one would expect it to be now almost *nil*. This is a heavy alteration for a stream whose first commerce was "the capture, curing and exporting of salmon caught in the river," and the Scottish saying that "Glasgow has made the Clyde, and the Clyde has made Glasgow," suggests that Glasgow should make the Clyde *clean*.

Seriously speaking, it is time for the city to realise that this chemical treatment alone is not justifying the expectations first held out, and the incubation test tells the same story, that the state of aeration in the river is gradually becoming worse. The other chemical figures given show irregular fluctuations.

The actual treatment in use is very elaborate and may be briefly described as follows. The doubly-screened and settled sewage is precipitated by lime and by "iron liquor," which is intended to be *ferric* sulphate, and is prepared in the "acid house." It is remarked, in Mr. Morton's paper, that the reagents being of a very destructive character all tanks and pipes carrying them have to be constructed with great care, and the roof trusses are all of timber with concealed metal fastenings: this implies that there is considerable acid vapour and spray. At first, the iron liquor was prepared by the direct solution of scrap iron in sulphuric acid, but it was found more economical to purchase ferrous sulphate crystals. These are dissolved in warm water, a small quantity of sulphuric acid added, and then nitrate or nitrite of soda, the mixture being sprayed in a wooden drum for about 45 minutes, when the oxidation is said to be complete. An average of 5 grains of lime and 8½ grains of iron salt is added per gallon of sewage. This, as stated, "involves the handling of 9·68 tons of burnt lime and 5·62 tons of ferrous sulphate in 24 hours." The quantity of iron is much greater than that used in London, where it has been 1 grain of ferrous sulphate per gallon. A saturated solution of lime water is used in preference to milk of lime.

A question arose as to the precedence of iron or lime additions, and as to whether the former should be ferrous or ferric, but all this is subordinate to the fact that the scheme of chemical precipitation alone leaves a good deal to be desired in the improvement of the lower Clyde. Although comparison with a detailed report I have before me, made by Sir E. Frankland in 1889, shows that the state of the river is now considerably better, attention should be given to the de-aeration which is still occurring.

COMBINED NITROGEN IN RAIN.

C. T. GIMINGHAM, F.I.C.
(UNIVERSITY OF BRISTOL.)

AT the time when the nitrogen question as affecting plant nutrition was a matter of keen controversy, Liebig, in formulating his "mineral theory," assumed that the ammonia in the atmosphere was the chief source of the plant's nitrogen. He must have held an exaggerated view of the amount normally present, but, none the less, it is essential in considering the possible sources of nitrogen available to a plant growing under ordinary conditions, to take into account the nitrogen brought into the soil from the air in rain, or by other means. Hence we need to arrive at an accurate figure for the amount of ammonia and nitric acid present in ordinary rain-water.

During the last few years a good deal of work has been published on this subject. The longest series of analyses have been carried out at Rothamsted, in Hertfordshire, and the results are summarised by Miller in a paper in the *Jour. Agric. Sci.,* Vol. I., p. 280. From 1888-1901, the average amount of nitrogen as ammonia and nitrates in the rain was 3·84 lbs. per acre per annum; and, approximately, this figure may be taken as applying to most rural areas uncontaminated to any great extent by impurities from large towns. Other figures recently obtained under similar conditions, but referring to less extensive series of analyses, are given below. Shutt (*Chem. News,* 1909, p. 305) reports that the amount of nitrogen in the rain and snow falling at Ottawa, Canada, during one year, was 4·32 lbs. per acre. Von Feilitzen and Lugner (*Jour. Agri. Sci.,* III., p. 311) find an almost identical figure for the year 1909, at Flahult, in Sweden—4·62 lbs. per acre; Hudig (*Jour. Agric. Sci.,* IV., p. 260), from results obtained at Uithuizermeeden, Gröningen, in the Netherlands, from July, 1908, to Dec., 1910, finds 5·89 lbs. per acre. These figures all refer only to ammonia and nitrates (with nitrites); but in addition, small quantities of organic nitrogen are almost always present in rain-water. At Rothamsted, this has been calculated as amounting to about one-third of the nitrogen present as ammonia and nitrates. We may, therefore, gather from these data that in rural districts the soil receives annually something between 5 and 6 lbs. of nitrogen per acre in the rain; and this, though a small amount, is by no means negligible in experimental work.

In addition to the nitrogen supplied in the rain, there is the possibility of a direct absorption of atmospheric ammonia by the soil. This point has recently been investigated by Hall and Miller (*Jour. Agric. Sci.* IV., p. 56), who exposed dishes of acid for considerable lengths of time and at various heights above the soil, and estimated the ammonia absorbed. Glycerol was used instead of water to prevent drying up, and determinations were made once a month for two years. It was found necessary to cover each dish with fine wire gauze in order as far as possible to exclude dust and insects, though this had the effect of reducing the free play of air over the dishes and possibly occasioned somewhat low results. The highest average figure over two years was only 1·58 lbs. per acre, and the discrepancy between this and the higher results obtained by other workers is probably to be accounted for by the exclusion of flies and dust. No certain conclusion could be drawn as to whether the soil is really an absorber or a source of ammonia, but, in any case, the total amount of absorption must be exceedingly small, and negligible for all practical purposes.

The presence of impurities in the rain may have quite other effects on vegetation than those due to the supply of a few pounds of nitrogen annually, and some work by Crowther and Ruston (*Jour. Agric. Sci.,* IV., p. 25) on the composition of the rain in the neighbourhood of a large industrial town (Leeds), deals with the question from another point of view. With an annual rainfall quite similar to that at Rothamsted they find that as much as 8·37 lbs. per acre of nitrogen as ammonia and nitrates, and a further quantity of 1·5 lbs. per acre as organic nitrogen, is deposited yearly, *i.e.*, a total of nearly 10 lbs. per acre per annum. This large amount of nitrogen is accompanied by much other impurity with disastrous results to plant growth. To quote only one other figure given—on an average of three years, the rain was found to contain "free acid equivalent to no less than 20 lbs. of sulphuric acid per acre yearly," the winter rainfall being more than twice as acid as the summer rainfall. This acid and the suspended matter in the atmosphere are shown by direct experiment to have a most deleterious action, both directly on the leaves of plants (curtailing assimilation, etc.), and indirectly by reducing the necessary bacterial activities of the soil. As the authors point out, there are large areas of such smoke-infested agricultural land in the North of England, and it is not unlikely that these results may prove generally applicable in such districts.

Municipal Chemistry.—At the Society of Arts, a Lecture was recently delivered on this subject by Mr. J. H. Coste, F.I.C. :—Although the Local Government Act of 1888 gave a great stimulus to municipal activity, the conceptions of the duties of local authorities had, for many years, been widening. With this growth sprang up the need for a class of officers whose duties are, on the whole, consultative rather than executive, such as medical officers of health, engineers, architects, and chemists.

The services rendered to local government by chemistry are of several kinds. Firstly, those which are the direct result of legislative enactment such as those of gas examiners, petroleum examiners, public analysts and agricultural analysts. Some of the Acts under which such appointments are made date back to 1860. A second class of services are rendered in connection with such normal duties as sewage disposal and the administration of Public Health Acts and other services of control. The executive work of maintenance of large residential institutions of various kinds normal to local government calls for the examination of very varied materials used in such institutions, in order that both sufficiently good materials may be obtained and yet freedom of contract allowed. The growth of municipal enterprise has led to a great deal of chemical examination of materials used either as stores or in constructional work. The utility of such examination has been questioned; it at least affords that balance of probability which, in the affairs of life, is generally admitted to guide choice imperatively. Advice in connection with legislation is often sought.

Arguments for and against "whole-time" appointments were considered, and the legitimate sphere of the whole-time man and the private practitioner considered.

The education of municipal chemists was briefly discussed.

Liquids under Tension.—A monograph on "Negative Pressure in Liquids," by Dr. Julius Meyer, has been issued as No. 6 of the *Abhandlungen* of the Bunsen Gesellschaft. A very detailed account is given of the phenomena of tension in liquids. Thus, in the case of water, measurements of the dilation were made over a range of temperatures from 0° to 31°C. and of pressures from − 7 to − 30 atmospheres; the coefficients of dilation under tension were found to be identical throughout with the coefficients of compressibility under positive pressures. The maximum density was raised by 0·0238° for each atmosphere of negative pressure as compared with a lowering of 0·0217° per atmosphere for positive pressures. Similar measurements were made with alcohol between 2° and 27°C. and from + 7 to − 36 atmospheres pressure: also with ether between 3° and 27°C. and from + 7 to − 36 atmospheres. The limiting of negative pressure indicated by Van der Waal's equation was not reached, but in the case of ethyl ether *a negative pressure of − 72 atmospheres was attained.*—T. M. L.

UNIVERSITIES AND COLLEGES.

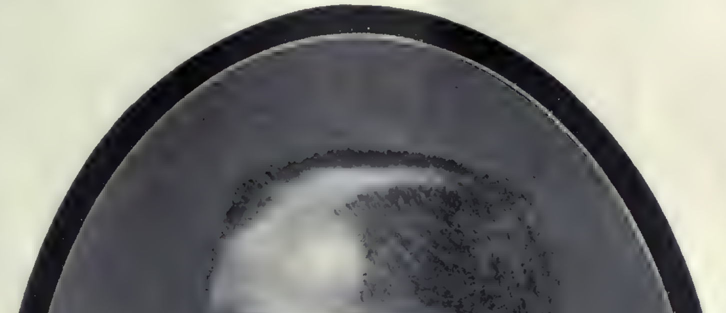
THE CHEMICAL DEPARTMENT OF THE UNIVERSITY OF BIRMINGHAM.

By HAMILTON McCOMBIE, M.A., Ph.D., and S. R. CARTER, B.Sc.

THE Chemical Department of the University of Birmingham dates from 1880, in which year the college founded by the munificence of Sir Josiah Mason was formally opened. The early work of the department was carried on under the direction of Professor (now Sir) William A. Tilden, and it is an interesting fact that the Chair of Chemistry is one of the four Chairs originally endowed by the founder.

The new Science College in the Midlands supplied a long-felt want, and students were not slow to take advantage of its resources for instruction in Chemistry and other branches of science. The classes were further augmented in 1882 when the Professors of Physiology, Botany and Chemistry voluntarily resigned their posts at Queen's Medical College, and agreed to transfer the teaching of these subjects to Mason College.

In 1894 Dr. Tilden was appointed Professor of Chemistry in the Royal College of Science, London, and he was succeeded in Birmingham by the present head of the department, Professor P. F. Frankland, from University College, Dundee.



Elliott & Fry.

PROF. P. F. FRANKLAND, D Sc., F.R S.

In 1898 an appeal was made for degree-conferring powers, and two years later the University received its Charter. From this time onward it became evident that the once roomy and convenient laboratories at Edmund Street were insufficient to meet the demands of the increasing number of students. The surroundings however, did not permit of any extension. The Engineering sections had already been comfortably housed in the new buildings at Edgbaston, and it was decided to allot one of the blocks to the Chemical Department. This magnificent group of buildings was formally opened by the late King Edward, in July, 1909, and before the close of the year, the transference of the work of the department to its new surroundings marked an important stage in its history.

The new buildings at Edgbaston have been designed to occupy positions radiating from a semi-circle. The Chemical block is situated at the western end of the curve.

The total floor space is 21,700 sq. ft., and, as this is divided between four floors, for the purposes of description, it is convenient to consider each floor in turn.

The lower ground floor is mainly devoted to the large Elementary Laboratory (42 ft. by 75½ ft.), which provides working accommodation for 96 students. The problem of keeping up a constant supply of sulphuretted hydrogen has been met by the installation of a large gasholder and generators. The gas is distributed to 14 small tap-jets, each of which is enclosed in a separate box, the whole being efficiently ventilated by an electric fan.

In addition to the usual fume cupboards each bench is furnished with a lead-lined hood, connected with the main flue-duct. The rest of the ground floor, as well as the mezzanine floor, is devoted to storerooms, etc.

On the upper ground floor is situated the Organic Laboratory, with accommodation for 40 students; the western end is provided with a balcony. Connected with this laboratory are the Operation Room, set apart for preparations involving large pieces of apparatus, and the Combustion Room. On the same floor are the Quantitative Laboratory and the Public Health Laboratory, which are arranged for 24 and 10 students respectively. There is also a dark room, divided into two portions, for spectroscopic and polarimetric purposes. The polarimeter is a large instrument by Schmidt and Haensch.

PHYSICAL CHEMISTRY LABORATORY.

The Combustion Room has space for 8 furnaces mounted on iron tables, and is very efficiently ventilated. Oxygen and air are stored in two large copper tanks placed under one of the tables, and are distributed by narrow pipes to nozzles placed beside each furnace.

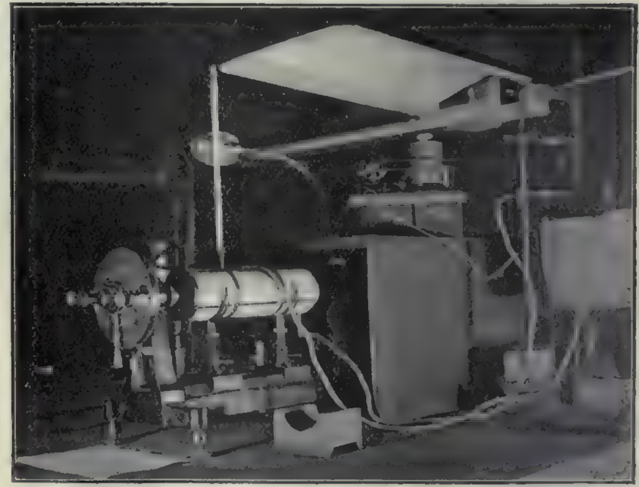
The first floor is occupied by the Physico-Chemical Laboratory, Electro-chemical Laboratory, Gas-analysis room, as well as the Professor's Room and the Research Laboratories.

The greater part of the second floor is occupied by the large Lecture Theatre, which is capable of seating 300 people.

There is also a smaller Lecture Theatre, accommodating 60 persons, while a Preparation Room is conveniently situated between the two Lecture Theatres. The Chemical Museum is also on this floor, and two well-appointed dark rooms utilise the space under the sloping floor of the Lecture Theatre.

The roof of the department, which is flat, has a portion sheltered by a glass screen and is supplied with gas, water and electricity.

Great attention has been paid to the efficiency of the ventilation. At one end of the block, where the large laboratories are situated, ventilation of the fume cupboards and hoods is obtained by means of 4 rotary fans placed in the four square towers at each corner of the roof. Each of these fans is driven by a 2-H.P. motor and the system is found to be most effective. At the other end of the block, where ventilation of only two small laboratories is required, gas jets are provided in the fume cupboards.



POLARIMETER.

The electrical equipment is on a very elaborate scale. The storage battery, which has a capacity of 240 ampère-hours, consists of 48 Tudor cells, and is divided into 8 groups of 6 cells each, one group being further divided. The plugboard is so arranged that the different groups can be connected in series or in parallel, and in the latter arrangement the battery has a maximum capacity of 500 ampères. An overhead network of bare copper wires passing through the various laboratories permits of a direct connection between the working benches and the cells, the necessary connections being effected on a large plugboard.

ELEMENTARY LABORATORY.

The cells are charged by an 11½ H.P. motor-generator set, consisting of a motor coupled up to two dynamos. The motor uses direct current; the necessary 440 volts being provided by the "outer" wires of the 3-wire system of the University power station. Each dynamo gives 50 ampères at 65 volts, and besides their use for charging the battery, can be run singly, or in conjunction with the battery, if required.

The installation includes a 35 kilowatt motor-alternator, and as the armature is wound in 4 sections, the operator is provided with a wide range of current density. Each section can give 350 ampères at 25 volts, and a parallel arrangement would thus give a maximum current of 1,400 ampères. Heavy copper bars, suitable for carrying this large current, are laid on to the Lecture Theatre and the roof.

The courses of instruction provided in the Chemical Department are many and varied. The first year, or

ORGANIC LABORATORY.

intermediate course, is designed to meet the requirements of first year students in Pure and Applied Science and in Medicine. The second and third year courses provide instruction in Inorganic, Organic, and Physical Chemistry for students taking the B.Sc. Degree, with Chemistry as a principal or as a subsidiary subject. Three years ago there was instituted a fourth year course for Honours candidates. Only a few lectures are given in this course, but the students must spend 24 hours per week in the laboratories. In addition to these courses there is provided also a course in Chemistry for Public Health students preparing for the Diploma in Public Health.

The M.Sc. Degree is granted for research work carried out after the B.Sc. Degree has been obtained. The increase in the number of research students has been very great since the new buildings were opened, and special facilities are available for students wishing to conduct research work. The department is fortunate in possessing three research scholarships, which have been founded in memory of Joseph Priestley.

The number of students in the Chemical Department (and indeed in the whole University) has increased most markedly within the last six years. The number of second and third year students in the session 1905-6 was under 30, while in the current session they exceed 50. A corresponding increase has been necessary in the staff, which now consists of the Professor, three Lecturers and three Assistant Lecturers and Demonstrators. The vast majority of the students adopt teaching as a profession, but a small number take up industrial work and public-analyst work.

THE ALLOTROPY OF SULPHUR. I.—POLYMORPHISM.

By T. MARTIN LOWRY, D.Sc. (Lond.).

THE term *allotropy* was introduced by Berzelius in 1841 to describe in the special case of the elements the phenomenon of identity of composition accompanied by wide divergence of properties. This phenomenon had been recognised half a century before in the case of carbon. But the allotropy of carbon was complicated by the impossibility of preparing the different allotropes in a pure condition. It was therefore to the element sulphur that Berzelius looked in order to illustrate in the case of the elements the phenomena to which in compounds he had applied the terms "isomerism" and "polymerism."

The word "allotropy," as defined by Berzelius, covers a number of very diverse phenomena. The present article deals with one of these phenomena, that of polymorphism. This depends on the diverse marshalling of the molecules in the crystals of the solid element; the allotropy is therefore confined absolutely to the solid state, disappears immediately on dissolution and is not associated with any diversity in chemical properties.

Polymorphism.—Mitscherlich's investigation (*Ann. Chem. Phys.*, 1820, *14*, 171; 1822, *19*, 350) of the arsenates and phosphates of the alkali metals, which led to his discovery of *isomorphism*, also resulted incidentally in the discovery of the first unequivocal case of *polymorphism*. On examining the acid phosphate and arsenate of sodium, NaH_2PO_4 and NaH_2AsO_4, he found that (unlike the potassium and ammonium salts) the two compounds were dissimilar in crystalline form: occasionally, however, crystals of the phosphate were obtained which had the form characteristic of the arsenate. This diversity of crystalline form, which is now known as polymorphism, had been suspected amongst minerals, but had usually been associated with the presence of impurities: in the case of sodium phosphate, on the other hand, the two crystalline forms of the substance could be prepared from pure materials or even from the same sample by mere recrystallisation; there was, therefore, no doubt as to their identity of chemical composition. In the following year (*Ann. Chem. Phys.*, 1823, *24*, 264) Mitscherlich discovered the same phenomenon in the element sulphur, and concluded that "*A substance, whether simple or compound, may affect two different crystalline forms.*"

"*Rhombic Sulphur*," S_I.—Crystals of native sulphur had been examined by Haüy (*Traité de Minéralogie*, 1801, *3*, 277), and shown to belong to the orthorhombic system. These crystals, when uniformly developed, have three axes of two-fold symmetry and three planes of symmetry perpendicular to these (Fig. 1): rotation of the crystal through an angle of 180° about any one of the axes would not alter the appearance of the figure; reflection of one half of the crystal about a mirror situated in any of the planes of symmetry would merely reproduce the appearance of the original crystal in its entirety. By evaporation of a solution of sulphur in carbon

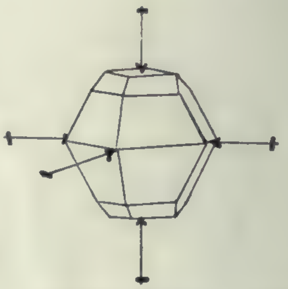


FIG. 1.—RHOMBIC SULPHUR. (HAÜY.)

disulphide, Mitscherlich obtained artificial crystals of the same form.

The lengths of the crystallographic axes, which occupy the same positions as the axes of symmetry, are in the ratios

$$a : b : c = 0{\cdot}81413 : 1 : 1{\cdot}90410.$$

"*Prismatic Sulphur*," S_{II}.—The second variety of sulphur was obtained by crystallising from fusion. Mitscherlich writes:

> "To obtain large crystals from fused sulphur, I melted, in an ordinary pot, fifty pounds of sulphur; I allowed the pot to cool surrounded with bad conductors of heat, during four to five hours; a thick crust was formed; I pierced this crust and, by inverting the pot, allowed the liquid sulphur in the interior of the mass to flow out; the crystals which I obtained in this way were sometimes half an inch in diameter. These crystals, freshly prepared, are transparent; but if they are exposed to the air they soon become white and opaque" (*Ann. Chem. Phys.* 1823, *24*, p. 266.)

When prepared on a small scale, this form of sulphur is obtained in long slender needles or prisms, the crystalline symmetry of which it is almost impossible to recognise. As prepared by Mitscherlich it formed compact crystals belonging to the monosymmetric system (Fig. 2.). These possess only a single axis of symmetry and a single plane at right angles to this axis. But although the symmetry is thus of a very low order, the axial ratios $a : b : c$ and the axial angle β between the inclined axes of a (nearly horizontal) and b (vertical) show only a slight deformation from the perfect symmetry of the cube, thus:

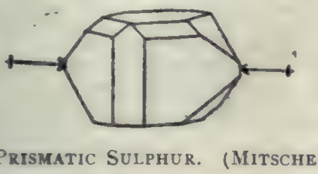


FIG. 2.—PRISMATIC SULPHUR. (MITSCHERLICH.)

Monosymmetric sulphur $a:b:c = 0{\cdot}99575 : 1 : 0{\cdot}99983$, $\beta = 84° \, 14'$
Cubic symmetry $a:b:c = 1:1:1$ $\alpha = \beta = \gamma = 90°$

The "pseudo-cubic" symmetry of this form of sulphur is an illustration of the very marked tendency, which has been noted by Barlow & Pope, for the chemical elements to crystallise in the simple forms (cubic and hexagonal) which can be produced by packing together equal spheres.

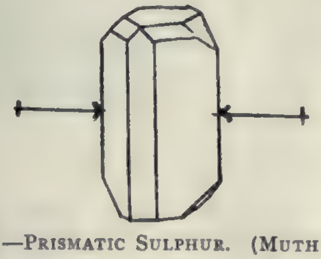


FIG. 3.—PRISMATIC SULPHUR. (MUTHMANN.)

After an interval of nearly 70 years well-formed crystals of this variety of sulphur were again prepared and measured by Muthmann in 1890 (Groth's *Zeitschrift 17*, 345). Muthmann's figure (Fig. 3) indicates the tendency of sulphur when crystallised rapidly to develop into prisms or needles, elongated along the vertical axis of c.

"*Nacreous Sulphur.*" S_{III}—The "nacreous" or mother-of-pearl variety of sulphur was discovered by Gernez in 1884. His directions for preparing it are as follows:

> "Nacreous crystals can be obtained very easily by dissolution: it suffices for this purpose to prepare in a sealed tube a supersaturated solution, without residue when hot, of sulphur in benzene, toluene, alcohol, carbon disulphide, etc., then to introduce the *end* of the tube only into a freezing-mixture—for example, into water to which crystals of ammonium nitrate are added; long nacreous flakes originate at the cold point, and advance little by little in the remainder of the liquid" ("On the Development of Nacreous Crystals of Sulphur," *Comptes Rendus*, 1884, *68*, p. 144, foot-note.)

Nacreous sulphur can also be prepared from fusion by melting the sulphur at 160°, immersing the U-tube containing the melt in water at 100° and serving with nacreous sulphur prepared from solution as described above. In this way crystals up to 4 to 5 cm. in length were prepared.

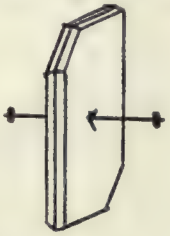


FIG. 4—NACREOUS SULPHUR. (MUTHMANN.)

Muthmann prepared the same variety of sulphur by the following method:

> "Five grams of pure, powdered sulphur were heated with $\frac{3}{4}$ litre of absolute alcohol for an hour under a reflux condenser; the solution was quickly filtered through a hot-water funnel into a warmed two-litre flask, which was then loosely closed with a cork. The flask was then immersed in a large six-litre water-bath, heated to about 70°; in order to produce a slow cooling, the exposed neck of the flask was covered with cloths. Proceeding in this way, after 12 hours' standing, a large quantity of glistening flakes of the third modification were regularly found to have separated; only rarely were rhombic prisms observed to have separated instead. The crystals are quickly filtered off and drained; the product formed under these conditions almost always contains a few crystals which are sufficiently thick for goniometric examination."

Crystals of nacreous sulphur were also prepared from alcoholic ammonium sulphide, as follows:

> "An excess of finely-powdered sulphur is added to saturated alcoholic ammonium sulphide and shaken thoroughly. The dark-red liquid is filtered, diluted with a little alcohol, and put aside in a tall loosely-stoppered cylinder. After a short time the liquid begins to lose its colour, and crystals separate on the surface; these may grow to 2 cm. long, and 1-2 mm. broad, but are, for the most part, extremely thin. . . . Those which I examined had taken four days to form, and were about 0·5 mm. thick."

Muthmann found that the pearly variety of sulphur, like the prismatic, crystallised in the monosymmetric system (Fig. 4). The different appearance of the two forms is due mainly to a difference of habit, the prismatic variety tending to elongate along one direction in the plane of symmetry, whilst the pearly variety tends to spread out in all directions parallel to this plane. There is, however, no close relationship obvious between the crystallographic constants of the two forms, those of the pearly variety being:

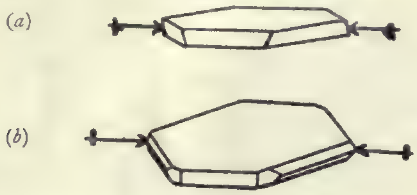


FIG. 5.—(*a*) TABULAR SULPHUR. (*b*) TABULAR SELENIUM. (MUTHMANN.)

$$a : b : c = 1{\cdot}06094 : 1 : 0{\cdot}70944,\ \beta = 88^\circ\ 13'$$

"*Tabular Sulphur.*" S_{IV}—The fourth variety of sulphur, to which the above name may be given on account of the characteristic form of the crystals, was discovered by Muthmann when preparing nacreous sulphur from ammonium sulphide.

> "I noticed sometimes on the walls of the glass, small thin tablets of hexagonal form, of which at first I took no notice, as I regarded them as crystals of ammonium sulphhydride. When I noticed that they changed suddenly on contact with crystals of other varieties, I was led to make a closer investigation, and proved that the tablets in question represent a fourth modification of sulphur. I made over 50 attempts to prepare it, of which not more than 5 were successful. Above 14° they do not appear to form. The temperature of the room was about 5°C." (*loc. cit.*, p. 343).

Although goniometric observations were very difficult on account of the extreme instability of the crystals, Muthmann was able to show that they belong to monosymmetric system and that their angles approximate to those of the stable form of selenium; thus the angle $\beta = 76\tfrac{1}{2}^\circ$ (circ.), the constants for Se_I being $a : b : c = 1{\cdot}63495 : 1 : 1{\cdot}5095,\ \beta = 75^\circ\ 58'$.

CURRENT LEGAL TOPICS.

By W. JAGO, F.I.C.

Flour Destruction Case.

A CASE in which points of considerable interest were involved has just been heard before the justices at Edinburgh. Acting under an order of the Medical Officer of Health, 600 sacks of flour were seized in a bakery of that town. This was in consequence of a discovery at one of the city hospitals that the flour in question yielded bread containing numerous dark spots. An application was accordingly made for a magistrate's order for the destruction of the flour. It was contended, on behalf of the owners, that the flour was of good quality, and that the defect was due to the presence in the flour of some kind of weevil, which could be entirely eliminated by a process of sifting. The magistrates, however, granted the order applied for, but subsequently heard an application that the order might be temporarily suspended, so that samples of the flour might be submitted to analysis. The argument was advanced for the defence that the flour was harmless, and could be made quite useful, and further that millers, brewers and others have frequently to deal with grain or meal that had become weevilly, and which could nevertheless be easily freed from these insects. The Court recognised the importance of the case, but before making the suspensory order, pointed out that the magistrate had already ordered that the flour was either to be destroyed or not to be used for human food or exposed for sale. Ultimately the magistrate decided to grant the suspension applied for, *provided that during the time the flour was not made fit for human food* or exposed for sale. Chemists can conceive of many ways in which, by accidental contamination with foreign matters, or by the non-removal of naturally associated substances an article of food can be rendered unfit for human consumption. And yet, by absolutely efficient, and perfectly harmless processes of purification, such food may be completely separated from the injurious ingredient. In cases such as these, if the health authorities discover the substance to be faulty, are the magistrates entitled to order destruction, notwithstanding that food can be efficiently purified? In this particular instance the magistrate's decision is likely to be made the subject of appeal.

R. *v.* Seddon.

At the moment of writing, a great poison trial (R. *v.* Seddon) has just reached its conclusion. It may be noted, that while the Crown alleged that the deceased person met her death by arsenic poisoning, this fact was not disputed on behalf of the defence, which called no scientific witnesses to rebut the evidence for the prosecution. The purely chemical aspect of the case is therefore comparatively lacking in importance. In clear cases of poisoning it is most satisfactory in the interests of the public that chemical science has now made the detection of poisons such a matter of certainty that the unedifying spectacle of analysts of eminence wrangling over the accuracy of each other's methods and tests is now but rarely seen. Perhaps the principal point of novelty in the evidence adduced, was that of the finding of arsenic in the hair and nails of the deceased person, and the conclusions to be drawn therefrom as to the date at which such arsenic must have been administered. It has been a general view that the presence of arsenic in these comparatively remote parts of the body indicated that it must have been administered some considerable time before death. On behalf of the prosecution, Dr. Willcox made some special experiments on this point, and came to the conclusion that the arsenic found in the hair had been deposited there after death and not during life. The deceased had been dead about two months on the exhumation of the body for examination. Counsel for the defence expressed the view that the Marsh test was a splendid qualitative one, but not good for quantitative purposes.

An appeal against the conviction has been heard and decided. The result is that the male prisoner has had his conviction affirmed. During the argument of counsel for the prisoner it was suggested that arsenical poisoning had not been definitely proved, but the point was not seriously contested.

Milk Powder in Butter.

Turning to less serious subjects, the ever-present conundrum of "What is butter?" has recently been again propounded to the magistrates. The charge was instituted by the Board of Agriculture against a London Creamery Company for having milk powder on their premises, which was intended to be used for the adulteration of butter. Although an element of the defence was that the substance was being stored on behalf of one of the directors, who was seeking to dispose of it privately, the defence justified the use of milk powder for the purpose of treatment of butter. On the defendants' behalf, Mr. Otto Hehner stated that it would be impossible to supply the public with butter of that uniform quality and flavour which was demanded, without blending, re-working, and renovating as carried on by the defendant company. For that purpose, said the witness, "the person who does not live in the middle of last century would use sterile milk powder." The butter sample taken on the Creamery premises contained 1·05 per cent. of lactose, as against 0·4 per cent. as a usual quantity. The witness submitted that the whole question is, "When does butter cease to be butter?" and answered it by the statement that "I always rule that if the article contains 80 per cent. of butter-fat it is butter." Mr. Vasey, who followed, said milk powder was of high nutritive value, and that if the public received an article containing 80 per cent. of butter-fat it was getting what it paid for. Similar evidence was given by two other public analysts, and in conclusion the magistrates dismissed the summons with £40 costs.

Assuming that the magistrate accepted the ruling of the witnesses, that if an article contains 80 per cent. of butter-fat it is butter, the door is thereby opened to somewhat extensive manipulations of that product. Taking for example New Zealand butters, the average of nine samples gave 90·8 per cent. of butter-fat. From butters of this type, 10·8 per cent. of butter-fat might be abstracted, and 10·8 per cent. of foreign fat substituted, and yet the article would be butter. If one excludes Irish butters, which are highly salted, and certain other examples of salt butters, there is among fresh butters a percentage of butter-fat which rarely falls below 85 per cent. Salt butters are a class to themselves, and, moreover, a class in which the public can at once detect the presence of salt; but in other butters the allowance of a margin of from 5 to 10 per cent. of fat for the vendors to "play with" is a degree of latitude which may operate to the serious detriment of the public.

PERSONAL AND OTHER NOTES.

The death of Dr. Edward Divers, F.R.S., late Emeritus Professor of Chemistry in the Imperial University, Japan, took place on the 8th April, after a long illness.

At a meeting of the Committee of the Lawes Agricultural Trust, held on March 30, Mr. A. D. Hall, F.R.S., Director of the Rothamsted Experimental Station, tendered his resignation, which takes effect in September. He will give his whole time to the work of the Development Commission. The Committee of the Lawes Agricultural Trust will shortly elect his successor.

A Director of the Department of Metallurgy in the Birmingham Municipal School is being appointed.

A series of Lectures on "Radio-Activity," by Hon. R. J. Strutt, F.R.S., at the Imperial College of Technology, is announced.

The Treasury grants for the last year to the following Universities are:—University of Birmingham, £13,500; University of Bristol, £7,000; University of Durham, Armstrong College, £8,500; University of Leeds, £12,500; University of Liverpool, £15,500; University of Manchester, £17,500; University of Sheffield, £7,000; University College, London, £16,000; King's College, £11,500; Bedford College, London, £7,000; London School of Economics, £4,500; East London College, £5,500; Nottingham University College, £5,700; Reading University College, £5,500; Hartley University College, £2,400. This leaves the Committee with a balance for this and last year's accounts of about £12,000.

CHEMICAL ENGINEERING.

A NEW SYSTEM FOR THE PRODUCTION OF VERY HIGH AND PURE VACUA.

By JOSEPH ZEITLIN.

DURING the past seven years the writer has been making experiments on the production of very high vacua—principally by means of a piston pump. The aim was to design a mechanically working piston-pump which should be capable of producing the highest vacua yet attained by a mercury pump, more rapidly and efficiently than by means of the latter; and so that, at the same time, the vacuum produced should be more pure, that is, free from traces of the vapour of mercury or other volatile substances (oils, etc.). This problem was considerably more difficult than was at first anticipated, and the numerous obstacles which had to be overcome can only be appreciated by those who daily have to use high vacua for industrial or other purposes. I will only deal with one or two of these, namely, those which led directly to the construction of the present type of pump.

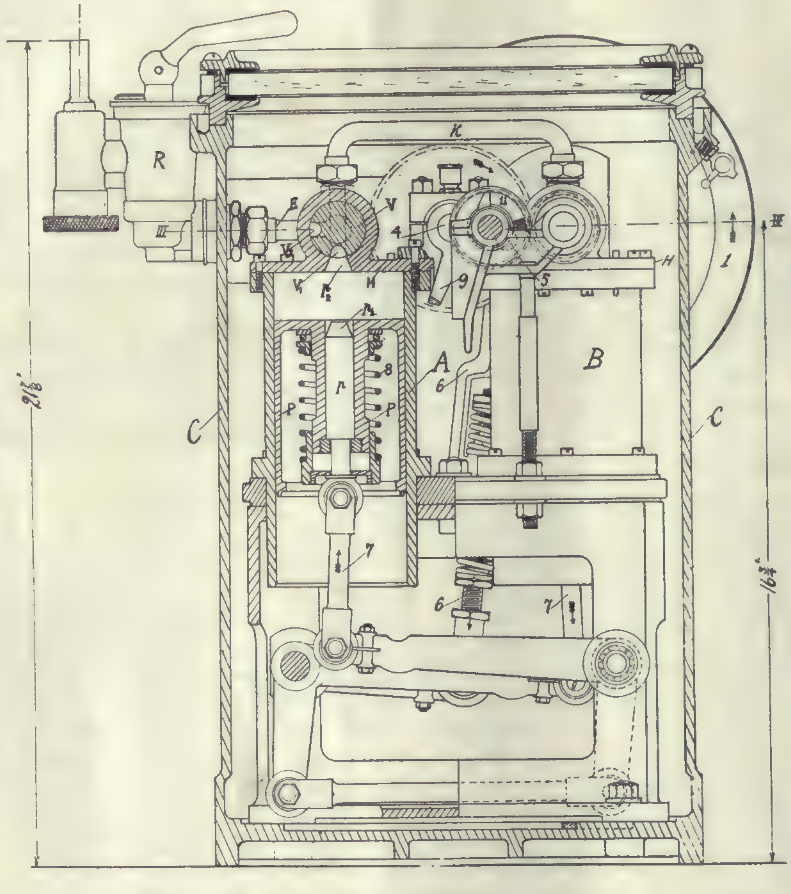


FIG. 1.—HALF-SECTIONAL ELEVATION ON LINES 1, 2.

The chief difficulty encountered was to protect the moving parts, such as pistons, cylinders and distributing valves, from leaks due to the atmospheric pressure, especially as it was decided not to use liquid or volatile lubricants for these parts. After several attempts, more or less successful, in the direction of improving the correlation of pistons and cylinders by means of different packing devices, it occurred to me to solve the problem in a more rational manner, namely, by removing the atmospheric pressure surrounding the pump, that is by arranging the vacuum pump itself to work in a vacuum.

It may be of interest here to point out that at that time when experimenting with a three-stage pump, and, contrary to expectation, the results were no better than from a similar two-stage pump, the apparent discrepancy between theory and practice was obviously due to leakage, and although generally an unknown quantity, it was always constant for each single pump so long as the pressure which caused it was constant. It appeared that if, while lowering the delivery pressure of a pump, we could also lower the pressure surrounding the pump so as to reduce or obviate the leakage, harmony between the theoretical and practical results would be re-established.

The first pump arranged to work in a vacuum was, with some modifications, the three-stage pump referred to, each of the units of which was capable of producing under ordinary conditions a vacuum of about 3mm.; when the three were put in series, a vacuum of about the same order was obtained, showing that considerable leakage was taking place. When two of the units were surrounded by a vacuum of 3 mm. (produced by the third unit) the vacuum at once rose to about 0·0001 mm. This value or $\frac{1}{7600000}$ atm. is approximately the cube of the ratio $\frac{1}{250}$, representing the performance of one unit, so that the result is very nearly that theoretically possible for this particular case.

This means of eliminating leakage proved so successful that it was decided to design a special type of pump, capable of working in these new conditions and deriving full benefit from them: *viz.*, a pump having elongating pistons, but without any packing or piston rings, so that all friction is thus avoided and the pump works without lubricants, either solid or liquid. The main protection against leakage is a comparatively high vacuum (1 mm. of mercury) round the pump.

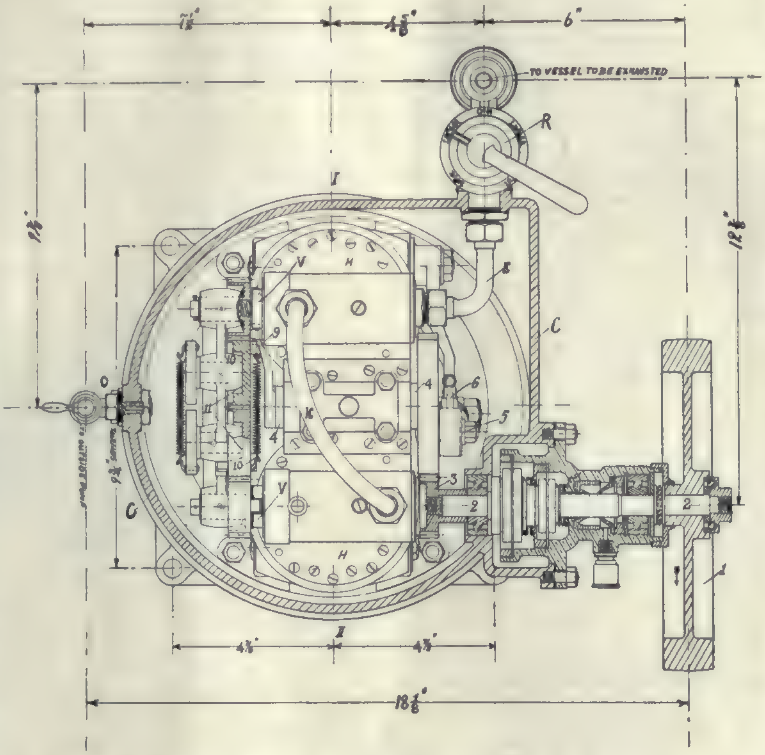


FIG. 2.—PLAN VIEW, WITH CASING IN SECTION ON LINE 3.

Before describing the drawings of the "Zeitlin High-Vacuum Pump," two important features may be pointed out, which explain its very marked efficiency:

(1) Mechanical elimination of all clearance or dead space.

(2) A 100% efficiency of piston stroke and port-area.

The clearance space at the end of the delivery-stroke is entirely eliminated by means of a compound piston and an elastic connection between this piston and actuating mechanism, the latter allowing the main piston to be driven right up against the end of the cylinder and afterwards bringing the auxiliary piston or "clearance plunger" to fill completely the port in the cylinder head, through which the gases are expelled. This auxiliary piston is mounted within the main piston and correlated with it in the manner seen in Fig. 1. The spring 8 tends to separate the two and thus the end p_1 of the plunger does not project normally beyond the main piston during the latter's whole movement, so that the main piston finishes its stroke completely before the clearance piston begins to enter the port, and therefore no restriction of the port area takes place during the complete stroke of the main piston. Further, the orifice of the port p_2 remains open to the delivery passage of the distributing valve V until the clearance plunger completely fills the said port.

It will be easily seen that such a compound piston, while eliminating all "dead space," gives ready means for the provision of ample port area for the free passage of the gases to be exhausted, which is important in view of the small pressures to be attained.

Cylindrical (or taper) distributing valves *V* are employed, and are mechanically operated. They are arranged to connect the port in the cylinder head alternately with suction and delivery ducts. The movement of the valves is an alternating intermittent one and takes place after the compound pistons completely finish their respective strokes and before they begin their next stroke; in other words, the pistons remain stationary at their extreme position while the distributing valves are moved—and *vice versâ*. Such an arrangement obviously gives the 100% efficiency above mentioned for piston stroke and port area.

The appended illustrations represent a 3½ in. by 4½ in. two-stage pump, arranged to work, enclosed in the air-tight chamber C, by means of an outside driving pulley 1, shaft 2,2, and pinion 3. The cylinder A is connected by means of an elbow pipe E, and stop-cock R, with the vessel to be exhausted; the pipe E passes air-tight through the wall of chamber C.

The delivery duct of the pump A is connected to the inlet of pump B by means of pipe K, while pump B delivers into chamber C, the evacuation of which is maintained by any outside auxiliary pump, at about 1 mm. of mercury. (The auxiliary pump is not shown, but it would be connected with the interior of the chamber C at O, Fig. 2.) Pinion 3 gears with the shaft 4, from which the pump pistons are driven by crank 5 through a double elastic connecting rod 6, a link motion adapted to reciprocate the pistons in opposite phases—and connecting rods F, which are coupled direct to the auxiliary pistons p, Fig. 1. From the section of the pump A in the same Fig., the construction of the compound pistons referred to above is clearly seen: the auxiliary piston p is mounted within the main piston P with limited longitudinal freedom between the two, controlled by the compression spring 8, keeping the clearance plunger p, with its end p_1 shaped to fill exactly the port p_2, withdrawn inside the main piston P, until the latter is driven right against the cylinder head H, when the spring 8 is compressed and the auxiliary piston forced to close completely the port p_2. The pistons and their actuating linkage remain stationary in this position for a period during which the crank 5 approaches and passes over the dead point, and the tappet 9, engaging a projection 10 on the face of one of the gear wheels 11, turns the distributing valves V through 90°, thus shutting off the delivery duct V_1 and bringing into register the admission duct V_2, or *vice versâ*, as the case may be.

During the stationary periods of the pistons, the remaining throw of the crank pin 5 is taken up by the shortening or extension of the double elastic connecting rod 6.

This pump of 3½ in. diam. by 4 in. stroke, working at 20 revolutions per minute, attains the very highest non-conducting vacua with great speed. Thus, in exhausting electric incandescent bulbs ten at a time, a non-conducting vacuum is attained in less than one minute, and all the gases which are driven off from the metal or carbon filaments by the electric current are withdrawn by the pump as soon as they appear, for each suction stroke of the piston means 0·64 litre of perfect undiluted vacuum in the cylinder. Ten is not the limit of the number of lamps with which this pump can deal at one time; 20 are dealt with almost with the same ease.

The results of the pump remain constant, whatever the changes in the atmospheric conditions of the room, as no mercury or other liquid is depended upon for the attainment of high vacua.

The vacuum produced by the Zeitlin pump, if measured by the electric discharge in a Crookes' tube, compares favourably with the highest vacua ever produced by mercury pumps, and is of the order of 0·02**M** to 0·01**M**,[1] as measured by Crookes.[2]

Such a vacuum is not readily obtained by mercury pumps without special elaborate precautions,[3] as the mercury vapour tension at the ordinary room temperature is in itself 50 to 100 times greater than the vacuum tension, and even at 0°C. it is 10 to 50 times greater, and while in the gaseous state mercury diffuses easily into the vacuum.

Measurements with a McLeod gauge show vacua of about $\frac{1}{86000}$ mm. pressure, which is $\frac{1}{48000000}$ of an atm.[4]

The absence of mercury or oil in the vacuum pump is not only advantageous for the ready attainment of a very high vacuum, but particularly for the use in spectrum analysis and scientific research, while the elimination of large quantities of mercury from a factory "pump-room" is also advantageous from a hygienic point of view.

The difference in the pressure on both sides of the pistons being very small, the power required to drive such a pump is less than 0·1 H.P.

The pump is efficiently protected from inrush of air, bits of glass or other impurities, by a trap and a check valve—both of which are correlated with stop-cock R.

The Zeitlin pump, working completely enclosed, is easily freed from the influence of any moisture; some phosphoric anhydride, in a small vessel, being placed inside the Case C.

I may perhaps be allowed, in conclusion, to express my great indebtedness to the late Sir Walter Palmer, whose continued interest and encouragement in this work were invaluable to me, and helped to attain the results now recorded.

THERMO REGULATOR FOR INDUSTRIAL PURPOSES.

By A. BALDWIN.

THE problem of automatically regulating the temperature during processes of manufacture has attracted the attention of many inventors, and various contrivances for effecting this purpose have been tried, and in some instances put to the test of continuous use. It cannot, however, be said that these have been either faultless or suitable for general application. James Baldwin & Co. have patented and placed on the market an apparatus that is claimed to be both simple in construction and suitable for general application. The temperature control is operated electrically, allowing freedom in fixing the different parts, which can be wired at almost any distance from each other in the usual way.

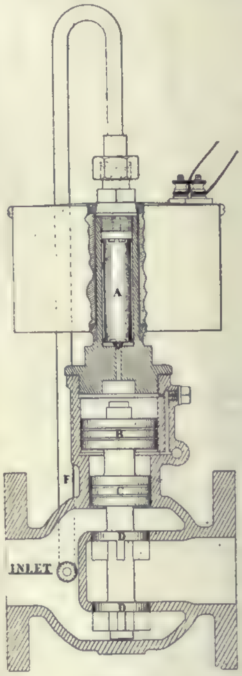


FIG. 1.

These parts consist of the Control Valve, Fig. 1; Thermometer, Fig. 2; and a Patent Transformer and Relay, Fig. 3. The Control Valve, Fig. 1, is fixed in the steam pipe on the outlet side of the usual stream regulating or stop valve, and must be fixed in a horizontal position, so that the internal parts operate vertically.

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[1] **M** stands for 1-millionth of an atmosphere.

[2] *Phil. Trans.*, 1881, p. 407.

[3] Crookes' *Phil. Trans.*, 1885, *95*, p. 693.

[4] This pump is manufactured by the Zeitlin Vacuum Synd., Ltd., 20 John Street, Adelphi, W.

The action of the valve is simple and readily understood, and is as follows:—As illustrated in Fig. 1, it is in the normal position, namely, "closed," when not under pressure. Instantly steam or pressure is admitted, the pressure acts upon piston C, and lifts, or opens, the main valves D D, allowing a full bore passage, at any, or varying pressures, for the fluid, to the vessel or other receptacle. This is an important feature. The valves D D are of the equilibrium type, and are cast on one stem with pistons C and B, the piston C being smaller in diameter than the piston B. In the cover of the valve body is placed a small valve A, in solenoid, having a connecting pipe F to the inlet, or pressure side of valves D D.

When under pressure valves D D are fully open, and pistons C B are forced up against the cover or end of cylinder on the outlet side of the small valve A. If the valve A be raised from its seating pressure passes along F and acts upon large piston B, forcing down into seating the main valves D D, shutting off supply. If the small valve A be allowed to fall on to its seating, the pressure upon the large piston B is removed (a small escape to atmosphere is arranged between the valve A and piston B), and the pressure acting on the piston C opens valves D D. It will be noticed that pistons B C and valves D D are operated by fluid pressure, and that the valve A in the solenoid is operated by electricity.

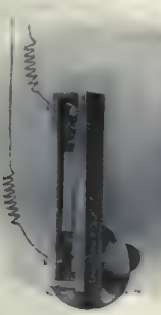


FIG. 2.

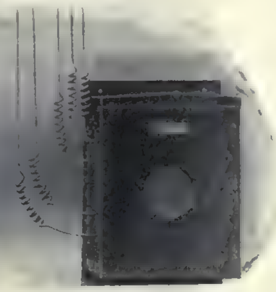


FIG. 3.

A specially constructed Thermometer, Fig. 2, is fixed in position on the vessel or receptacle, and is calibrated for required temperatures. This thermometer, acting as an electric switch operated by temperature, is fitted with terminals. One terminal connection is made into the bulb, the other end of the tube being left open to the atmosphere. In this open end is inserted one end of a platinum wire, the other end of the wire being connected with the remaining terminal. The end of the wire in the tube is set opposite to any temperature on scale required.

The current that passes through this thermometer must of necessity be very small, and for this purpose the Patent Transformer and Relay, Fig. 3, is used to complete the apparatus, which is connected by wire in the usual way. The whole operates as follows:—Steam or other fluid passes the valve and acts upon the thermometer. The temperature rises until the mercury touches the platinum wire at the given temperature, completing the circuit with relay through thermometer, which, in turn, completes the circuit between the mains and the solenoid. This lifts the small valve A from its seating, and closes main valves D D as before described. Upon the temperature falling and breaking the circuit in the thermometer, the circuit to the solenoid is broken through relay, releasing valve A, which drops on to its seating, shutting off the pressure on piston B, the main valves D D opening as before described.

The "Isothermal" Governor is economical in the quantity of current used, being at 230 volts ·4 ampère, at 110 volts ·5 ampère. It is used only when the steam or fluid supply is controlled, or shut off automatically by the thermometer.

This Governor is in use for many purposes in the manufacture of chemicals where processes require constant temperatures:—

On small tanks for testing purposes, the contents being maintained within 0·75° F. For the dyeing of piece and other goods, in open and enclosed vessels, the temperature during the process of boiling being maintained within 1° F. For wool-drying machines, steady uniformity being secured in heating to within 2° F. of the desired temperature, permitting a corresponding accuracy to the finished wool. In cotton and worsted spinning and wool-combing rooms the benefits of the "Isothermal" Governor are being experienced, temperatures varying not more than 1° F. being maintained. A saving in the consumption of steam over old methods is thus obtained. Many other applications for this automatic control of temperature will probably suggest themselves to the industrialist.

CORRESPONDENCE.

The Editor will be pleased to publish letters dealing with subjects which may be of general interest.

Red Mangrove Bark in Madagascar:—The rapidly increasing use of this bark in tanning is well illustrated in the following figures of production:—

Year.	Metric tons.
1905	137
1906	1,408
1907	2,026
1908	3,754
1909	22,105
1910	36,181
1911 (six months)	24,441

The forests cover an area of 220,000 acres. The labour cost of producing the dry bark is said to be 20s. to 24s. per ton. The total output goes direct to Hamburg. The wood is used cally for building and fuel purposes; also for charcoal.

THE INFLUENCE OF THE CHEMIST UPON THE ENAMEL INDUSTRY.

By Herbert H. Hodgson, M.A., B.Sc., Ph.D.

Enamelling is one of the famous arts of antiquity, specimens of coloured enamelled earthenware having been found in the ruins of Thebes, while many references to the adorning of ornamental vessels with enamel occur in the writings of classical authors, such as the Elder Pliny.

The practice of enamelling has thus been handed down from early times, and in consequence has experienced a progressive evolution. While gold, silver and copper were exclusively the metals to be enamelled by the ancients, it remained for the nineteenth century to effect the transition from nobler metals to iron and steel, and so transform the former art into an enamel industry.

For a considerable period the enamel industry made but slow progress owing to the false ideas in vogue, which regarded everything from a purely empirical standpoint and sought to accomplish all things by means of inelastic formulæ and jealously guarded works' secrets.

The industry was destined, however, to attain enormous economic significance, and the commencement of this advance dated from the moment when crude empiricism broke down before the assault of scientific method. In other words the entrance of the chemist was the signal for rapid development to ensue.

Several factors combined to effect the great result. Chemical industry began to furnish enamel manufacturers with pure products at a cost hitherto unheard of. Iron and steel makers produced a soft basic steel, which was ideal for enamelling purposes. Investigations into firing processes, ventilation conditions, and products of combustion, made by such scientists as Fischer, Bunte, Orsat, etc., brought into being vastly improved modes of heating and created a fuel technology. It only remained for the enameller to adapt himself to the new conditions in order to achieve success beyond anticipation.

The great problems to solve were those of establishing the conditions for a harmonious union of the enamel with the sheet steel, whereby difficulties due to expansion could be overcome. Crude empiricism was now on its trial. A leading American firm sought to meet the inconvenience, due to changes in the physical and chemical structure of the steel produced during the different processes, by an electrolytic nickelling of the rough wares previous to enamelling. In France the experiment was tried of welding different brands of iron together, but with only partial success. To Germany, however, was reserved the honour of discovering the correct solution, which lay in producing a new series of enamels capable of adapting themselves in such matters as expansion to the metallic surface.

Again, popular opinion had to be educated, in face of the many calumnious objections levied against the use of enamelled wares. Here the research chemist played a wonderful part by securing the total abolition of poisonous additions, such as compounds of lead, and replacing these by more efficient and at the same time innocuous substitutes.

At the outset enamels were laid on by the so-called powdering process, which consisted in dusting the enamel upon the red-hot object by means of a finely meshed sieve until the necessary thickness of coating was attained. Improvements were soon introduced, whereby enamels were applied in a moist condition and then fired in a muffled furnace.

The chemical industry, with its enormous output of raw materials, has rendered the chemist indispensable in an enamel works. All the substances used must be submitted to his inspection, since the quality of an enamel is intimately bound up with the chemical character and purity of its individual constituents. A few instances of the raw materials, adulterations, and substitutes will serve to illustrate this point. The principal ingredients used for enamel recipes are felspar, borax, quartz and cryolite, with smaller additions of soda, saltpetre, stannic, cobalt and nickel oxides, magnesia, limonite, clay and colouring matters. The felspar must be obtained in lump only, as opposed to the increasing employment of powdered spar, for in this way alone has one the certainty of always buying the same product free from admixture with cheap quartz, etc. Great care must also be exercised that the felspar is not contaminated by earthy matters, coal, etc., such as may be gathered from ship and truck. In the case of borax the fluctuating water content must be under control, since alteration in weight may cause serious error during admixture. Both natural and artificial cryolites are used in the enamel industry. Recently many sodium silico-fluorides have found employment, these being obtained for the most part as by-products in the manufacture of artificial manures. During the manufacture of this substitute for natural cryolite, common salt is used as a precipitating agent, and therefore the presence and amount of sodium chloride must be determined before the addition of sodium silico-fluoride. Again, artificial cryolite will contain more or less quartz or silica, according to its cheapness, and neglect to estimate these, will bring about variations and failure in enamel preparations.

The oxides of cobalt and nickel are most interesting from the standpoint of this article, since they illustrate the influence of the chemist to the fullest extent. Originally the naturally occurring smalt served for the blue colouring of enamels, but owing to its fluctuating cobalt oxide content, only a variable colour intensity could be secured. An important forward step was taken by the preparation of pure cobalt oxide. It is not, however, for colouring purposes alone that cobalt oxide has its value, but also from the fact that by it the ground enamels may have their co-efficients of expansion adjusted to that of sheet-iron. Research has still further contributed to the economic side by substituting the much less expensive nickel oxide for the above purpose.

An interesting field for chemical investigation is that dealing with opacity-producing bodies. Here stannic oxide is an absolute necessity. Owing, however, to the rising price of tin, efforts are continually being made to find a suitable substitute. While for the moment success has not rewarded the attempts, yet a wealth of new matter has been brought to light. Antimony compounds appear to act well as substitutes, but, unfortunately, are banned in many countries owing to fear of poison. Titanium oxide appears to hold out great promise, since not only does it produce opacity, but, like the oxides of nickel and cobalt, it imparts most favourable physical properties to the enamel; the problem for the moment is to discover its most suitable mode of application.

It is essential that the purest water should be used when grinding enamel in the wet way.

Again, the chemist is an important factor in all the firing operations, whereby economy in fuel and efficiency in conduct are secured, while his investigations into the relationship between chemical composition and properties of the metals used, have contributed in no small way to the remarkable progress achieved by the enamel industry.

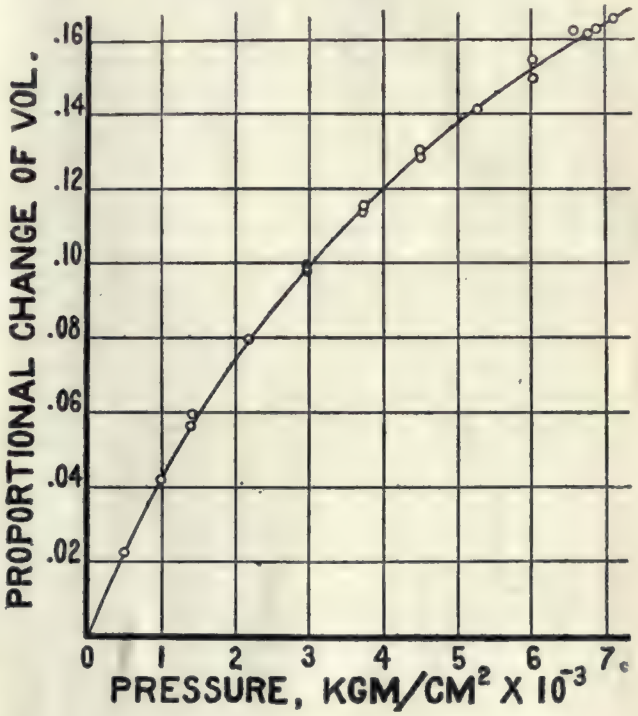
The influence of the chemist may be seen at every stage of the actual enamelling operations. The crude wares, before coating, are heated to redness, with the object of not only removing the adhering greasy or soapy layer, but also of restoring the elasticity to the sheet metal which has been lost during the forging, drawing, planing or pressing processes. The wares are then pickled, *i.e.*, placed for a short time in an acid bath with the object of producing a rough metallic surface to which the enamel can adhere better and more intimately. Here a comparatively innocent-looking operation bristles with knotty problems, awaiting solution. One or two examples will illustrate the field which this subject offers. Freshly compounded acid baths are inactive at first, but become active when some pickling liquid from a previous operation is added; the explanation of this peculiarity may probably be found in catalytic causes called into being by the gradual formation of hydrogen. According to recent investigations, the pickling process has the greatest influence upon the quality of the sheet steel, and Ledebur has found that when certain foreign substances are present in the steel the effect of pickling is modified, *e.g.*, a silicon content appears to diminish the injurious action of the pickle, while a carbon content intensifies it.[1]

Enough has been said to demonstrate most effectively the influence and opportunity of the chemist in this important industrial field.

ICE AT 76° C.

By T. MARTIN LOWRY, D.Sc. (Lond.).

Tamman's experiments on water and ice under pressures up to 3,500 atmospheres, described in the February issue under the title "Ice, Water and Steam," have been extended in a remarkable way by P. W. Bridgman (*Proc. Amer. Acad.*, Jan. 1912, *47*, pp. 441-558), who has extended the measurements up to the amazing pressure of 20,000 atmospheres. The metastable variety of "light ice" could not be detected in these experiments, but the author recognises its possible occurrence by reserving for it the name of Ice IV. suggested by Tamman. The second variety of dense ice (Ice II.), which Tamman regarded as a metastable variety of ordinary dense Ice III., is shown to be the stable form at temperatures below 33·4° at 2290 kg/cm^3 and below $-26{\cdot}0°$ at 3220 kg/cm^2. The difference in volume between the two varieties is so small that the equilibrium is determined more by temperature than by pressure; the small difference of volume is also responsible for the fact that the equilibrium-curve was not discovered by Tamman.



The most striking of Bridgman's discovery is that of two additional varieties of ice existing in the region of higher pressures. Ice V. is formed in place of Ice III. at $-17°$ under 3530 kg/cm^2, and is displaced in its turn by Ice VI. at $+0{\cdot}16°$ under 6380 kg/cm^2.

Ice VI. is remarkable in that it only appears *above* 0°*C*, and its freezing point has been traced up to 76·35°C. at 20670 kg/cm^3, a temperature at which the ice would be uncomfortably hot and a very useless material for the purpose of refrigeration! The range of pressure over which it exists is at least twice as great as that of the other five forms of ice, and there are indications that this is perhaps the final form of the solid. One of the curves is reproduced.

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[1] For further information the reader may consult Grünwald's "Enamelling on Iron and Steel." C. Griffin & Co., London.

THE PHYSICS AND CHEMISTRY OF COLLOIDS

By Emil Hatschek.

CHAPTER V. (*Continued.*)

In the last two chapters we have considered systems in which the disperse phase—whether of microscopic or ultra-microscopic dimensions—consists of solid or, more correctly, rigid particles, and we now proceed to the study of systems of two liquid phases. These present several very striking peculiarities which can only be properly explained by observing either natural or artificial "emulsions," *i.e.*, fairly coarse dispersions of one liquid in another, with which it is not miscible. Both natural and artificial systems of this kind are numerous and important: of the former we may mention milk, which is an emulsion of fat globules in a solution of caseinogen, albumin, lactose and salts, and rubber latex, in which the continuous phase is also a solution of proteids, while the disperse phase consists of rubber and resin globules in varying proportions. As regards the artificial emulsions, some of them are unwelcome by-products of various industrial processes, such as the condense water from steam engines which contains a portion of the oil used for cylinder lubrication in a state of very fine and persistent division, or wool washings, in which some of the wool fat is emulsified by the action of the soaps formed from a portion of the fat. A large number of emulsions are also prepared purposely, such as a number of well-known pharmaceutical preparations, lubricating compounds, etc.

The simplest systems of this class are the pure "oil-water" emulsions, which, as the name says, contain no soaps, proteids or other emulsifying agents. The type of these is condense water, with about one part of oil in ten thousand or more of water; very similar emulsions may be obtained by pouring an alcohol or acetone solution of an oil into water, when the oil separates in the form of very minute globules. In this way it is possible to obtain stable emulsions containing up to one-thousandth part of oil. This great dilution is quite in keeping with what we know already about the suspensoids, and investigation of such oil-water emulsions, which has been carried out during the last few years by Lewis, Ellis and Goodwin, and the author, shows that they do not differ materially from systems with solid particles. The oil globules show active Brownian movement, are coagulated by electrolytes and can even—as was first shown by the author—be retained by certain filtering media, for instance by the ultra-filters mentioned in a previous chapter. This possibility proves that very small liquid particles approaching ultra-microscopic dimensions possess a high degree of rigidity, a conclusion fully borne out by mathematical investigations carried out by the author.

While, therefore, systems of two liquid phases containing only a small percentage of widely separated particles differ in no material respect from similar systems with rigid particles, a very important difference appears as the percentage of disperse phase increases. With rigid particles this percentage is obviously limited by simple geometrical considerations. If we imagine the particles to be spheres of equal diameter and to be so numerous that they are in closest contact—in which case each sphere touches twelve others—they occupy about 74% of the total volume. Such an arrangement of *solid* particles will, however, no longer have the properties of a liquid, but will be a mud or paste: filter press cakes of, *e.g.*, calcium carbonate, which still contain about 40% of water, or only 60% instead of 74% of solid matter, certainly no longer resemble a liquid. If the disperse phase is liquid, that is, still easily deformed, it is obvious that the whole system will still retain the character of a liquid, even if the disperse phase occupies, or, indeed, exceeds 74% of the total volume. The globules will touch one another when the former figure is reached, and as it is exceeded will become flattened at the points of contact, developing the twelve faces of a dodecahedron. There is thus no limit to the ratio: volume of disperse phase/total volume, which may approach unity. As a matter of fact, emulsions containing 99% of oil in 1% of soap solution have been made by Pickering.

It is quite impossible to prepare emulsions containing such percentages of disperse phase (or anything more than fractions of a per cent.) unless the disperse phase is a solution of certain substances, such as soap, various products of the saponification of albumin, or one of the saponins. All these solutions have one characteristic in common: they froth strongly even in great dilutions. Frothing, which never occurs with pure liquids, is a definite indication that the dissolved substance lowers the surface tension of the solvent, and the process of emulsification is closely connected with this lowering of surface tension, or more correctly the interfacial tension between the two phases. This connection can be very easily demonstrated by an apparatus devised by Donnan, and illustrated in Fig. 8. A pipette A is provided with a length of capillary tube B, which leads into a bend C. The latter is drawn out into a point D, which is ground off flat. The pipette is filled with the oil to be examined, and the outlet submerged in the liquid which is to be the disperse phase. The size of the drop which issues from the point D is settled on one hand by the difference in specific gravity of the two liquids, and on the other by the surface tension acting round the circumference of the point, which tends to retain the drop. Any decrease in surface tension accordingly shows itself in diminished size, or increased number of drops, and this increase, and the obvious parallelism between it and the emulsifying power of the liquid, is very striking. While, for instance, a pipette used by the author gave 65 drops of light petroleum in water, it gave about 260 drops in a 1% soap solution. With such a soap solution it is quite easy to make emulsions containing over 90% of petroleum as disperse phase, and this percentage may be increased still further by certain methods indicated by Pickering.

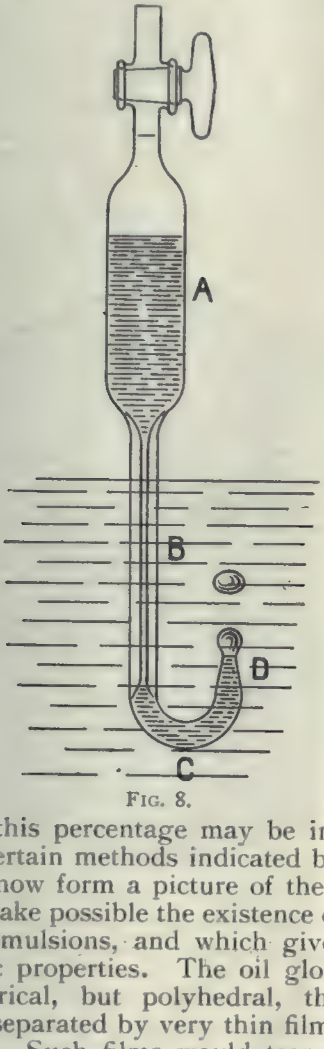

FIG. 8.

We can now form a picture of the various factors which make possible the existence of these high percentage emulsions, and which give them their characteristic properties. The oil globules are no longer spherical, but polyhedral, the adjoining faces being separated by very thin films of the disperse phase. Such films would tear, if they had the high surface tension of water, and can only persist if the interfacial tension, which tends to tear them, is very greatly lowered by certain dissolved substances. If the films are thick, *i.e.*, if the particles are widely separated, a persistent emulsion is possible, as we have seen above, even in water. We also realise that such a system consisting of polyhedra of oil separated by thin films of an aqueous medium—or, put in the other way, a honeycomb-like structure of the latter filled with oil—must have the high viscosity which is so characteristic of the emulsions with a large percentage of disperse phase. If such liquids are sheared, the polyhedra will constantly have to slide over one another, and in the process will be stretched and deformed. In other words, the total surface of the system will be enlarged and, notwithstanding the low surface tension, a considerable amount of surface energy developed, which appears disguised as viscosity. Extreme cases are presented by some of Pickering's emulsions with 99% of oil, the viscosity of which is so great that they can be cut into cubes and retain their shape.

The stability of emulsions made with one of the emulsifying agents mentioned above varies considerably. Generally speaking, they are destroyed by the addition of all substances which affect the latter: thus emulsions made with soap solution are at once destroyed by the addition of small amounts of acid, which decompose the soap. Rubber latex is coagulated by such substances as coagulate the particular proteids which it contains, for instance, acetic acid in the case of Hevea latex. The phases can often be separated without the use of chemical agents, by centrifuging, as in the case of milk. Finally, as the globules are—generally negatively—charged, they travel in the electric field, and this method has at least been suggested for industrial application.

The actual methods of making emulsions—suitable qualities of the phases being assumed—deserve only passing mention. The two components are shaken up together until the disperse phase is sufficiently finely distributed, or the "oil" is injected into the other liquid from a syringe with a fine nozzle. Temperature naturally plays a considerable part in these operations, as it reduces the interfacial tension between the phases, and also their viscosities.

We now proceed to the consideration of the second—and by far the more important—class of colloids, the emulsoids. The only inorganic emulsoid of much importance is silicic acid, which was very exhaustively studied by Graham. If a solution of sodium silicate ("waterglass") is decomposed by a slight excess of hydrochloric acid, and the mixture is dialysed until the free acid and the sodium chloride have been removed, there remains in the dialyser a perfectly clear colourless sol of silicic acid. This sol, either spontaneously or on addition of electrolytes—carbonates or phosphates being particularly effective—sets to a bluish and almost transparent gel. No water separates, *i.e.*, the gel contains the same amount of water as the sol, and the transformation is irreversible, that is, the gel cannot be dissolved again. The change is also, as far as can be ascertained, continuous: the viscosity of the sol increases steadily until it becomes immovable, this feature forming an important distinction between gel formation and the solidification of molten substances, which is discontinuous. Silicic acid sols and gels are supposed to have existed in considerable quantities at some geological periods, and various minerals, like agate and opal, probably owe their origin to such gels.

(*To be continued.*)

FURTHER EXPERIMENTS ON THE CRITICAL POINT AT 470°C. IN COPPER ZINC ALLOYS.[1]

By Professor H. C. H. Carpenter, M.A., Ph.D.

This critical point was found to occur at 470°C. in all alloys containing the so-called "β" constituent as a separate structural entity, *i.e.*, from about 63 to 40 per cent. of copper. The interpretation advanced by the authors was that "at 470°C., on cooling, β splits up into an intimate mixture of α and γ; on cooling, the reverse change takes place." This resolution of β into $\alpha + \gamma$ the authors considered they had detected microscopically in an alloy containing pure β, just above 470°C. It appeared, however, to be only visible at very high magnifications. Photographic evidence in support of this view has been previously given in a paper, and also of the homogeneity of β above 470°C.

The experimental data which constituted the evidence for this interpretation were not questioned by anybody either in the lengthy discussion or voluminous correspondence which followed. The interpretation, however, was challenged. It was alleged by Messrs. Rosenhain, Huntington, Desch, Hudson, and Johnson, that the photographic evidence for the duplex structure demanded by the theory given in the paper was inconclusive.

Another objection was raised by Messrs. Desch, Guertler, and Rosenhain, who drew attention to the non-coalescence of the so-called $\alpha + \gamma$ complex, even after the three weeks' annealing experiment at 350°—400°C. carried out by the authors, and asserted that if the theory was correct this coalescence should take place to such an extent as to render the α and γ particles visible at much lower magnifications than 1,000 diameters. This criticism is very important, and it must be satisfactorily met before the above theory can be regarded as established. Accordingly, as explained in a foot-note by the writer (p. 193) at the conclusion of the joint paper, fresh experiments were set in hand by him in order to obtain decisive microscopical evidence of the interpretation of the critical point.

The actual compositions of the alloys came out as follows:

No. 1. Copper, 54·20 per cent.; Zinc, 45·77 per cent.
No. 2. ,, 50·35 ,, ; ,, 49·61 ,,

These fulfil the required conditions. The former is 0·7 per cent. to the left of the β boundary, and contains this slight excess of α; the latter is 0·65 per cent. to the right, and contains this excess of γ. In all the experiments to be described these alloys were heated in small sealed glass cylinders in order to avoid any changes in composition.

Experiments with Alloy 1 containing a Small Quantity of Free α.

The etchings reagents found most suitable in all the succeeding experiments are either a moderately concentrated solution of ferric chloride in aqueous hydrochloric acid, or a 25 per cent. solution of ammonia (0·88 specific gravity) in water, to which a few drops of hydrogen peroxide are added immediately before use. The magnification of the photomicrographs is, with one exception, 150 diameters. At this magnification it appears a typical β alloy with large darkly etching and apparently homogeneous crystals. Round the upper part of the large almost central crystal will be observed a thin white border, in one part continuous and smooth, in others discontinuous and jagged. This is free α. In the first instance this alloy was heated for three days in a small electrically-heated annealing muffle, fitted with an adjustable resistance, which enabled the temperature to be kept between 420° and 430°C. The microscopic examination of this specimen gave some most interesting information. Certain β crystals appeared entirely unaltered. A very few, not more than about twelve in the entire field, $\frac{5}{8}$ inch by $\frac{5}{8}$ inch, were found to have undergone the typical eutectoid inversion into alternate light and dark somewhat curved lamellæ. These are surrounded by darkly etching crystals in which a number of white specks (of α) are manifest. This photograph by itself is sufficient evidence that the so-called homogeneous β is in reality a two-phase system. Its similarity to the well-known iron carbon eutectoid "pearlite" is very striking. Evidently, then, in this specimen there were a number of crystals of exactly the eutectoid composition. It is well known, however, that the lamellar type of eutectoid structure is not stable on prolonged heating. It tends to pass into a granular or even globular variety. A careful scrutiny of this photomicrograph shows not only some comparatively coarse lamellar eutectoid about the centre of the field, just disappearing, but also much finer lamellæ, mixed up with the granular type, into which they are passing. By far the greater number of originally apparent β crystals, however, had been resolved into the type of structure shown in Fig. 1. They showed a granular structure in which a very large number of white specks appeared on a dark ground. Even here, however, it will be observed that the lamellar type of structure has not entirely disap-

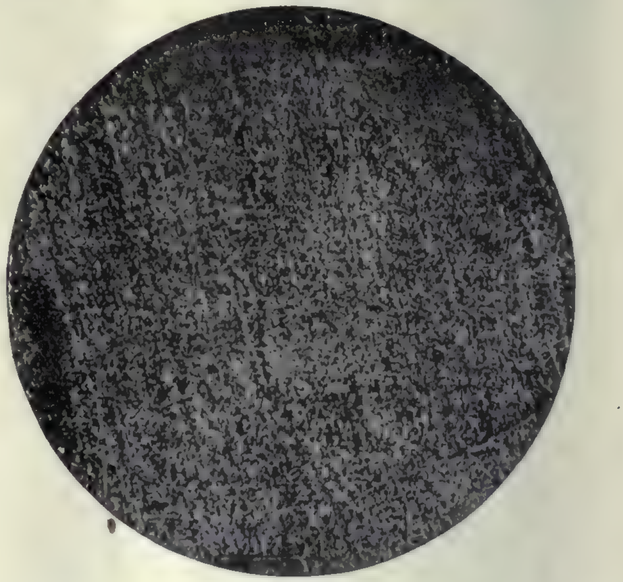

Fig. 1.

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[1] Institute of Metals, Jan., 1912.

peared. These white specks are the α crystals coming out of the approximately $\alpha+\gamma$ eutectoid, and there is no doubt that this crystallisation is due to the presence of the comparatively small number of free α crystals originally present which are able to exert their crystallising influence at the temperature of the experiment on the remainder of the alloy. The crystallisation of α from another specimen heated for ten days in sulphur vapour is of great interest, because it shows two types of crystallisation on one large crystal in the centre. In the upper half the α appears as a series of approximately parallel needles of varying thickness, whereas in the lower half it has come out almost entirely in the form of specks. It will not escape observation that the main band of α on the top of the large crystal is jagged, and that the direction of the jadded edges is the same as that of the needles in the interior. It certainly looks as though the latter type of crystallisation has been induced by the particular direction of the jagged edges. On the other hand, the α band at the bottom of the large crystal is smooth, and it does not appear to have exerted formative influences on the crystallisation of α in its sphere of influence.

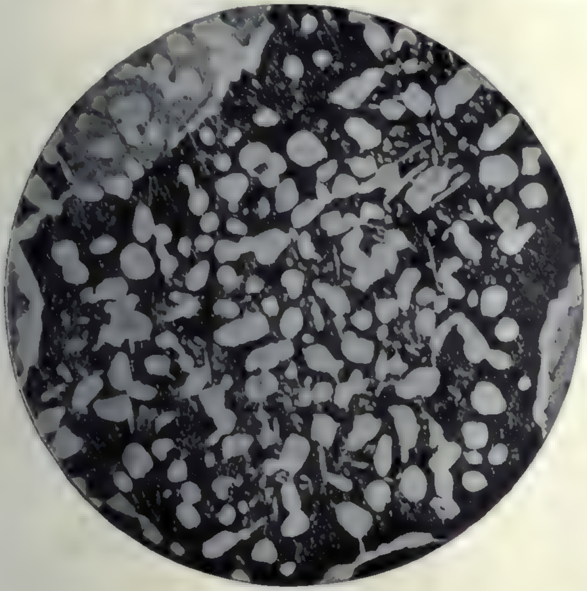


FIG. 2.

Fig. 2 shows the coalescence of α into coarse crystals after three weeks' annealing in sulphur vapour. This is accompanied by a rounding of the sharp edges. A further stage is seen in Fig. 3, after five weeks at 445°C. This shows the coarse crystals coalescing to large irregularly shaped masses. Finally, Fig. 4 shows the enormous α crystals (white), on a dark ground of γ, after eight weeks at this temperature. On this specimen the α crystals can be seen perfectly well with the naked eye. Thus the final result is α (light) + γ (dark) in an extremely coarse state of aggregation such as the theory demands.

One more step, however, had to be taken to make the proof complete. It might be objected that in spite of the precautions taken the composition of the alloy had changed during the above experiments, and that the structural changes shown had been caused by this and not by the coalescence of the products of a eutectoid inversion. To meet this possible objection the specimen was heated for twenty-four hours at 700°C. in order to destroy the large crystals and bring about the reaction

$$\alpha + \gamma \longrightarrow \beta.$$

After this it was allowed to cool in the ordinary way, and photographed. The result showed that the structure has been replaced by typical apparent β areas, and that a few specks of α are distributed here and there. This proves that the composition of the alloy has not changed, and that the apparently homogeneous β has really been resolved into the two constituents $\alpha + \gamma$.

EXPERIMENTS WITH ALLOY 2 CONTAINING A SMALL QUANTITY OF FREE γ.

The structure of this alloy α, as cast and slowly cooled, when lightly etched it is seen to consist of large areas of apparent β, while along their original boundaries and, to some extent, in their interiors are dotted crystallites of free γ, which appears as a greyish light-blue constituent (appearing light on the dark β background). The structure obtained after ten days in sulphur vapour was as follows : γ appears as a large number of light bluish-grey spots on a ground of apparent β, whose colour may vary from a golden-yellow to a deep brownish-black. The latter appears dark in the photomicrograph, while three small areas of the former, approximately equidistant from one another, appear light. The development of γ is slower than that of α, and in no case were any crystals observed undergoing the lamellar eutectoid inversion such as is seen on the α side.

The structure after three weeks in sulphur vapour is of particular importance. It represents the junction of three large areas and one small area of apparent β, with a considerable development of γ, which, however, does not etch uniformly. In the top left-hand area γ appears *light* on a medium ground. In the top right-hand area it appears *dark* on a light ground. At the junction of these two areas it will be seen that a given γ crystal appears both light in one part and dark in another, according to its position on the apparent β areas. In the large area at the bottom the γ crystals are some of them light, others dark, and others again mottled. But in spite of these differences of etching, there is never any difficulty in deciding which is γ and which apparent β. The explanation of these differences will be given shortly.

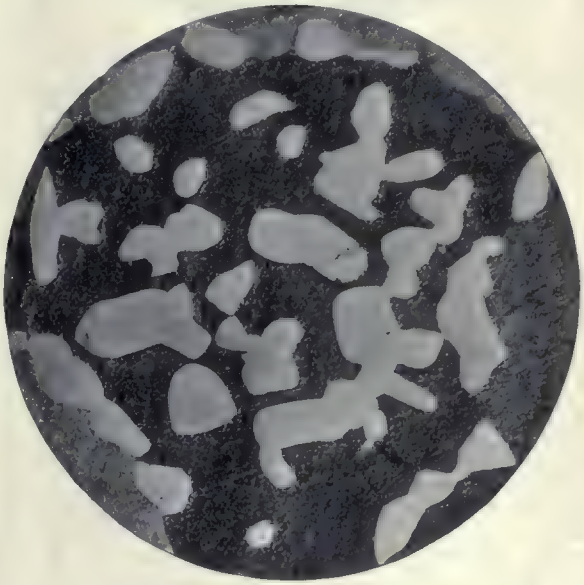


FIG. 3.

After five weeks in sulphur vapour, and in this and in all subsequent specimens tested, γ etches dark.

The development of γ after seven weeks. Owing to its brittleness it is apt to break up and fall out to some extent in polishing. In this particular instance the three large crystals placed almost horizontally in the centre of the field are parts of one originally very large crystal. For this reason the proportion of γ in any field is generally less than would be anticipated. After nine weeks' annealing the large central crystal appearing in relief is γ. It appears light bluish-grey in a field of pale gold α. On etching, the colour of α does not change, whereas γ is covered with a deep purple film. Other characteristic small γ areas can also be located. The reason for the somewhat varying behaviour of γ towards etching reagents during its crystalline development from apparent β is as follows :—The colour of what may be called massive α is pale gold, that of massive γ pale bluish-grey. In the originally cast specimen of apparent β with a few γ crystals, the former is coloured by etching reagents a deep reddish-brown; the latter is unaltered and so keeps its colour. But as the annealing progresses and γ is withdrawn from the apparent β, leaving a relatively higher proportion of α, there comes a moment when the etching properties are reversed; the enriched α areas no longer etch, whereas the γ areas do, and they are covered with the characteristic purplish film. It represents the moment when this "change-over" has begun in some parts, but not in all. It has taken place in the right-hand but not in the left-hand area, and the bottom area is just in the transition stage. After the change-over is completed, γ always etches dark with respect to α.

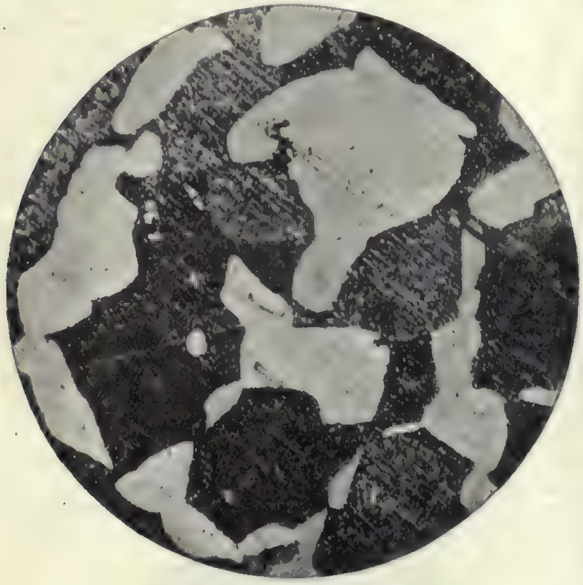


FIG. 4.

The characteristic colours of α and γ appear in the specimen containing a slight excess of α. Here the γ is the matrix from which α has crystallised, and owing no doubt to the fact that even after eight weeks' annealing the separation of α is still incomplete, the form of the γ areas is rather indistinct, though the characteristic colour can be seen.

Thus the final result of the annealing experiments on No. 2, *containing a slight excess of free* γ, *is the same as that in* No. 1 *in the sense that the products are* α *and* γ. In order to complete the proof the specimen, annealed for nine weeks, was heated for twenty-four hours at 700°C. so as to destroy the α and γ crystals and reform β. After cooling it was seen that the typical structure of apparent β had been restored, showing that the composition has not been changed.

It appears to the author that the explanation of the critical point at 470°C. in the β constituent of copper-zinc alloys advanced by Mr. Edwards and himself a year ago, *viz.*, that on cooling it is resolved into an intimate mixture of α and γ, has now been proved in an overwhelmingly conclusive manner. Every requirement of the theory has been satisfied, and it possesses all the certitude of verified prediction. The theory demanded that with sufficiently long annealing under the right conditions, the two alloys—No. 1 consisting of apparent β with a small quantity of α No. 2 consisting of apparent β with a small quantity of γ—should be resolved into a mixture of coarse α and coarse γ; further, that though the type of crystallisation would be different in the two cases, because in one case α crystallites and in the other γ crystallites were employed to upset the persistent structural equilibrium of the eutectoid mixture, yet the α and γ should etch in the same way in the annealed alloys, and, finally, that by annealing under the proper conditions it should be possible to destroy the coarse α and γ, and reproduce the original apparent β. Each of these requirements has been satisfied, and it appears to the author that all reasonable grounds for scepticism have now been removed, and that this theory is firmly established.

The proof that below 470°C. the so-called β constituent in copper-zinc alloys really consists of a very intimate mixture of α and γ particles is important, because it explains what the author has always regarded as an anomaly in the etching properties of this substance. It has always appeared surprising why β should be coloured so deeply and so rapidly by etching reagents, and further why, although β etched more easily than α, it also etched more easily than γ. The last-named contained more zinc, and might be expected to etch more readily than β. Both these anomalies are now explained. Apparent β colours deeply and rapidly because it really consists of an intimate mixture of minute particles of α and γ, which dissolve very readily in etching reagents. In this respect it closely resembles the so-called "Troostite" of the iron-carbon system, which is now known to be a similarly intimate mixture of iron carbide and iron. Thus all the conditions for rapid etching are present, and this explains why apparent β etches more readily than well segregated γ. The latter is no doubt electro-positive to the real β, *i.e.*, above 470°C., but it does not dissolve as readily as the extremely fine particles of γ in the $\alpha + \gamma$ eutectoid mixture. When, however, such as under the conditions that have been described γ is withdrawn from this mixture, resulting in an enrichment of α, then the apparent β no longer etches so readily, and it has been shown that it is the γ that then colours so deeply.

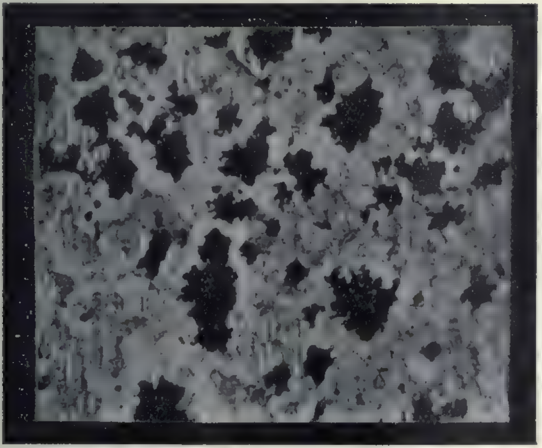
The Theory of Sulphuric Acid Manufacture.—Reynolds and Taylor have recently contended, before the Society of Chemical Industry, that Raschig's statement that sulphuric acid is formed in the lead chambers by the interaction of nitrous and sulphurous acids, with formation of two hypothetical compounds, nitrososulphonic acid, $ONSO_3H$, and nitrosisulphonic acid, H_2SNO_5, is founded on experimental errors. They have proved (1) that the only gaseous product of the action of sulphurous acid on nitrous acid is nitrous oxide, the nitric oxide formed in Raschig's experiments being due to the presence of potassium iodide as an indicator; (2) that chamber crystals can exist in solution in 60% sulphuric acid, the latter fact invalidating Raschig's account of the formation of Sabatier's violet acid (Raschig's nitrosisulphonic acid). Divers modification of Raschig's theory is also rendered untenable by these facts.

REVIEWS OF BOOKS.

"CAST IRON." By W. H. Hatfield. CHARLES GRIFFIN & Co., LTD., London, 1912. Pages 249+vi, including Index and Appendices. Chapters XV., including 164 Illustrations, with Frontispiece and Photomicrographs. Price 10s. 6d. net.

This important work is typical of the class of modern text-books which deals with a special subject in detail. It is in itself a satisfactory book of reference to the work which has been accomplished by recent methods in establishing useful data about metals, and their internal structure under varying conditions of purity, and strain.

The extraordinary advance which has followed the careful study of metal surfaces after a process of selective etching is brought to notice, and illustrated by a carefully selected series of photo-microphotographs, which have been published from time to time. One of these is now reproduced. This account includes the author's own valuable work in this direction.


WHITE CAST IRON SUITABLY HEAT-TREATED.

The influence of the presence of silicon, phosphorous, sulphur, manganese and other elements such as vanadium, chromium, nickel, nitrogen, etc., is dealt with in detail, and such practical questions as those of the influence of casting temperature, shrinkage and contraction in cast-iron, are seriously considered. The remaining portion of this book is taken up with a consideration of the mechanical properties of cast and malleable cast-iron, and decarbonisation of cast-iron without fusion. The effect of heat treatment is dealt with in very satisfactory detail. Finally, a chapter is devoted to the question of furnaces and slags. The fact that a foundry iron containing 6·93% impurities may contain 35·73% by volume of compounds formed therefrom, will indicate the extreme importance of a study of the subject from a point of view other than that of chemical analysis.

The student will peruse the pages of this work with great advantage, and the author will hardly fail to be repaid for his careful labour by the natural demand which must certainly follow the production of this useful text-book.

"AN INTRODUCTION TO THE STUDY OF FUEL." By F. J. Brislee. CONSTABLE & Co., LTD., London, 1912. Pages 269+xiii, including Index and Appendices. Chapters XVI., including 62 Illustrations with Frontispiece. Price 8s. 6d. net.

This is the first contribution to a series of text-books dealing with the chemistry of national industries. This book is one, which in general terms, gives an account of the principles of chemistry and thermo-dynamics, which underlie the use of fuel under modern conditions of working. After a fairly complete account of the analysis of fuel and flue gases, the calorimetric determination of heating values, high temperature pyrometry, and the calculation of combustion temperatures, the natural and artificial solid fuels are described at some length.

Gaseous fuel, and the manufacture of producer, water gas, and blast furnace gas is considered from the theoretical and practical sides. The author has probably some reason for omitting anything but a passing reference to the recovery of by-products, which may place such an important part in the ultimate selection of the method adopted in obtaining power.

The theory of explosion engines, furnace efficiency, and fuel economy are treated in a practical manner, and a chapter is devoted to the question of liquid fuels. The book is well illustrated, and has a distinct use in bringing to the notice of the student or manufacturer many points of great interest in the consumption of fuel. Mathematics is avoided wherever possible, and when introduced, treated in as simple a manner as is consistent with clear expression.

"A DICTIONARY OF APPLIED CHEMISTRY." By Sir Edward Thorpe. LONGMANS, GREEN & Co., London, 1912. Vol. I. Pages 758 + viii. Numerous Illustrations. Price 45s. net.

This is the first volume in the new edition and proves to be a valuable contribution to modern chemical literature, dealing as it does in general terms with the applied side of the science.

Advance has been so rapid since the last edition was completed that the new one runs to five volumes, instead of the original three. As a "first aid" to knowledge of the subjects treated, it may be relied upon to give general information and to supply references to general literature, thus pointing out further and more extended sources of information.

It is impossible within the compass of this review to do more than indicate that, under the able guidance of Sir Edward Thorpe, the writers who have contributed to this dictionary have satisfactorily carried out their allotted work.

The articles dealing with analysis, brewing, the carbohydrates, cellulose, and cement seem to be particularly well done, and if the future volumes are up to the standard of the first one, as can hardly be doubted, the editor is to be congratulated on continuing a work which cannot fail to be of every day use to the general chemist.

"A SCHOOL CHEMISTRY." By F. R. L. Wilson and G. W. Hedley. THE CLARENDON PRESS, Oxford, 1912. Pages 572 + vii, including Index and Appendix. Chapters XXXII., including 97 Illustrations. Price 4s. 6d.

On examining the pages of this book one is struck by the businesslike manner in which the facts are marshalled and the satisfactory way in which the diagrams convey their meaning. We think that the schoolboy who works with this text-book should gain a working insight into his subject and should escape from many a pitfall, as the instructions are of a very practical nature.

We have no hesitation in recommending this book to the notice of science-masters, and others, on the lookout for a satisfactory elementary text-book for their students.

"AN ELEMENTARY TEXT-BOOK OF METALLURGY." By A. H. Sexton. C. GRIFFIN & Co., Ltd., London, 1911. 5th Edition. Pages 263 + xi, including Index. Chapters XX., divided into 2 Parts. 71 Illustrations. Price 6s.

This edition is practically on the same lines as the previous one, very few alterations having been made. As an elementary introduction to the subject, it seems to have met with a very satisfactory circulation, probably because it not only deals with the actual reduction of metals, but in a preliminary way with such subjects as combustion, fuels, furnaces and the occurrence of metals in Nature. To the student commencing the study of metallurgy it is certainly to be recommended.

"QUALITATIVE CHEMICAL ANALYSIS OF INORGANIC SUBSTANCES." By Olin Freeman Tower. P. BLAKISTON'S SON & Co., Philadelphia, 1911. 2nd Edition. Pages 84 + xiii, divided into 7 Sections, including Appendix. Price $1.00 net.

This is one of the many books which deals with the elementary side of qualitative analysis, and the fact that it has been necessary to print a second edition indicates that there is some call for it on the other side of the Atlantic.

This introduction deals in some detail with the question of reversible reactions, law of mass action, dissociation, precipitation, hydrolysis, etc., and may serve in its way as a useful introduction for the elementary student to such subjects, when it is not possible for these to be taught in class.

Books Received.

"SMOKE," by Julius B. Cohen and Arthur G. Ruston. Edward Arnold, London, 1912. Pages 88, including Index and Appendices, 35 Illustrations, with Frontispiece. Price 5/- net.

"WATER ANALYSIS," by Herbert B. Stocks. Charles Griffin & Co., Ltd., London, 1912. Pages 136 + vi, including Index and Appendices, 8 Illustrations. Divided into 2 Parts. Price 4/6 net.

"CAST IRON," by W. H. Hatfield. Charles Griffin & Co., Ltd., London, 1912. Pages 249 + vi., including Index and Appendices. Chapters XV., including 164 Illustrations, with Frontispiece and Photomicrographs. Price 10/6 net.

"THE CHEMISTRY OF THE RUBBER INDUSTRY," by Harold E. Potts. Constable & Co., Ltd., London, 1912. Pages 153 + viii., including Index. Chapters VI. Price 5/- net.

"AN INTRODUCTION TO THE STUDY OF FUEL," by F. J. Brislee. Constable & Co., Ltd., London, 1912. Pages 269 + xiii, including Index and Appendices. Chapters XVI., including 62 Illustrations with Frontispiece. Price 8/6 net.

"SOME STREAM WATERS OF THE WESTERN UNITED STATES," by Herman Stabler. Water-Supply, Paper 274. United States Geological Survey. Pages 188, including Index. Government Printing Office, Washington, 1911.

"MANUFACTURE OF NITRO-LIGNIN AND SPORTING POWDER," by Earle Durnford. Pages 84. Whittaker & Co., London, 1912. Price 5/- net.

"METHODS OF AIR ANALYSIS," by J. S. Haldane. Charles Griffin & Co., Ltd., London, 1912. Pages 130 + viii, including Index, with 24 Illustrations, including 1 Plate. Price 5/- net.

"VOLUMETRIC ANALYSIS," by Charles H. Hampshire. J. & A. Churchill, London, 1912. Pages 104 + vi, including Index. Chapters XI. Price 3/6 net.

Methyl Alcohol in Ethyl Alcohol.—Most of the tests used to prove the presence of wood alcohol in grain alcohol depend on the presence of certain impurities in the former, which almost invariably accompany it, among which acetone is the most important. The D.A.B.V. contains a test for the presence of acetone in ethyl alcohol, which, when positive, is supposed to show the presence of wood spirit in the grain alcohol, but no test is given which will show pure methyl alcohol, free from acetone. Such a test has been proposed by Deniges, and is described again by Jungclauss. One-tenth of a cubic centimeter of the alcohol under examination is treated in a test tube with 5 cc. of 1 per cent. permanganate solution and 4 drops of pure sulphuric acid, decolourized after 2 or 3 minutes with 20 drops of 8 per cent. oxalic acid, treated with 20 drops of pure sulphuric acid, and shaken well. To the clear solution is then added 5 cc. of fuchsine-sulphurous acid solution, and the tube set aside. If methyl alcohol is present, a delicate violet-blue makes its appearance, which passes into reddish violet. All other aldehydes give a colour immediately, which soon fades, but the colour produced by formaldehyde increases in intensity for some time. The fuchsine solution contains 0·1 g. fuchsine, 88 g, of water, and 0·7 g. of sodium bisulphite, to which 25 drops of concentrated hydrochloric acid are added after an hour. (*Jungclauss, Apoth. Ztg.*, 1912, p. 30.)

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER III. (*Continued.*)

WHEN this is fully recognised, as it will be one day, the relationship between industrial and pure chemistry will correspondingly improve. These two sections are but branches of the same science: the one is complementary to the other.

There is no real significance in reactions conducted on a ten gramme basis, which is not equally apparent, when they proceed on a scale measured in tons; nor is there any special magic, beyond that of convenience, in the glass beaker or the platinum boat, which is not equally present in the salt pan or the blast furnace.

The student should aim at a wide experience, and knowledge of a general nature, so that he may be equally at home in different branches of research. Experience of this order can alone make him a successful investigator under the conditions which must obtain in the future. He must take a wide view of his subject, and be prepared to follow up investigation in whatever direction it may take. This is a task of considerable difficulty, but one which must be met by the modern investigator.

CHAPTER IV.

CHEMICAL AND GENERAL SCIENTIFIC INVESTIGATION.

"For the Pseudo-Chymist seeks gold, but the true Philosopher, Science, which is more precious than any gold."

AT the present day theory is held of little account unless it conforms with any experimental evidence which may be available: past investigation to a great extent determines its natural limits. Under this essential condition the influence of theory on practice has been far reaching and beneficial in its effect. The value of theory is regarded as of such importance in certain directions, that investigations which do not involve some point in theory are regarded as standing on a lower plane.

Thus research which is connected with industry, or some practical application, is ranked as of a secondary order. Under modern conditions this position may have to be reconsidered in many cases.

The condition that theory must fall into line with practice or be discarded, has limited false pretensions on the one hand, and on the other has given it additional value in practical investigation. A full knowledge of the theory of any subject for the time being should thus be regarded as an essential factor in all investigation, full allowance being made for any tendency which may exist in certain directions to overload practice with theory. For the latter in that case defeats its own end. The normal state must be one in which practice and theory advance hand in hand.

There can be no doubt as to the value of theory which is sustained on a substantial basis of fact. This is demonstrated daily. The practical investigator will make all use of this important factor as an aid to advancement in his investigations.

Research in Relation to Pure Science.—In this case investigation is confined to the consideration of natural phenomena. It does not concern itself with practice, except where it incidentally deals with changes which also play some part in industry.

Research of this order deals with the nature of natural phenomena, and an expression of the results observed in terms which meet the special requirements of the branch of science involved.

It deals with the investigation of phenomena which are only partly understood, examines past results in the light of more recent experience, and extends knowledge in every possible direction, determining for the time being its limits. Its programme is specific and self-contained. Any practical application of the results obtained is outside its sphere. It aims at a knowledge of the ultimate state and condition of matter, and its attendant phenomena.

Research of this nature is under modern conditions generally subsidised in some shape or form. It may be carried out at the University or College; it is generally confined to those able to conduct such work without the direct hope of pecuniary reward.

It is not correct to assume that the results obtained have no practical interest, or that they may not sooner or later have some definite value in the hands of the practical investigator. Thus a general consideration of the theoretical conclusions is of vital interest to the technical investigator, and incidentally such applications have an equal interest to the worker in pure science. For they often confirm views on a more widely set area than can possibly be obtained in the laboratory.

It is therefore necessary for the practical man to keep closely in touch with theory, and the worker in pure science to have some knowledge of the results of the practical application, and use of, such conclusions, and the way they may be modified by more general experience.

Thus the investigator must have a special knowledge of general facts, so far as they may be expected to influence his results and work, and examine the conclusions which have been arrived at in any branch of science which may seem to be directly, or indirectly involved in his investigation.

The general question of this practical application and use of theory is therefore a most important one, as this extension must in many cases ultimately determine its actual value. Chemistry is essentially an experimental science, and it must, as in the past, justify its existence on the grounds of general utility, and not of theory. From the point of view of progress, the relationship between the different branches of investigation should be as intimate as possible.

The value of research in pure science is supreme. It is directly responsible for progress along definite lines. It has set up a constantly changing system which has been followed in its natural development with a certainty of procedure which is based on a belief in the ultimate value of the methods involved.

In combination with theoretical speculation, it has secured a further advance in knowledge, which may be defined as of a less definite order. In effect this has secured a position for chemistry which has hardly been equalled in any other branch of science. No other branch of experimental work can be said to have escaped its influence. Its importance to industry is beyond all question.

It is impossible to judge the approximate value of theory as it is represented by present ideas. At some time in the future, the benzene ring may have less significance than a daisy chain, but it has made for progress. Speculations on space formulæ and the attendant models may be an equally inefficient application from an ultimate standpoint. They may belong to the childhood of science, but in spite of all that can be said in this direction, the value of such speculations is seen in the practical advancement which has followed in their train. Thus theory forms one of the most interesting branches of any experimental science. It plays a definite and essential part in the general scheme of progress.

Relation between Chemical and General Science. —This is increasingly intimate under modern conditions. Any advance in a special subject necessarily becomes of interest to many branches other than the one under which it receives classification. It may often throw unexpected light on investigations in seemingly quite other directions.

The development in experimental chemistry has been so widely spread, that the ever increasing volume of recorded data brings with it a natural tendency to specialisation on the part of the investigator. Thus the true relationship between the different branches of experimental science may be overlooked, and the student will do well to remember that this tendency to specialisation is not to be encouraged before it is forced upon the investigator. The effect of too early a specialisation is continually brought to mind by a study of some of the records of modern investigation.

The present position is the opportunity of the young investigator. The results obtained in comparatively new branches, like those of bio-chemistry, electro-chemistry, and others which might be mentioned, are demanding an ever-increasing recognition from investigators working in other directions. These inter-developments are setting up new conditions, and increasing the available knowledge which may be brought to bear on any specific research, by establishing a more definite relationship between the physicist and chemist.

(*To be continued.*)

COMMERCIAL AND GENERAL NOTES.

A Useful Substitute for Horn and Celluloid.

Artificial substitutes for materials for industrial purposes have frequently proved themselves to be of almost greater commercial value than the real article. This helped to dispel the natural prejudice of the public against substitutes in general, and to encourage inventors to use their best efforts in order to produce useful substitutes. An invention of some importance has recently been discussed in a German technical paper. The subject of the invention is a substitute for horn, celluloid, galalith, and similar substances which are used in such magnitude for different industrial purposes. The new material, which has been put on the market under the name of "Rauschitt" is very homogeneous, elastic and tough. Bending readily it may be formed into almost any shape, and its high polish is not affected by atmospheric influences. This latter quality distinguishes "Rauschitt" from a few other celluloid substitutes, such as galalith or bakelite, which lose their glossy surface when exposed to damp air, being extremely hydroscopic. "Rauschitt" can be made either transparent or opaque. Its specific gravity is 1·20—1·30, but it can also be produced with a density similar to that of ivory, *e.g.*, 1·70—1·90. The artificial horn can be coloured in any desired shade. Even the waste scraps which are left over after working the material into articles may be used again. It is a useful substitute for vulcanite and promises to attain some importance in the electrical and chemical industries. Consisting of thin sheep horns, which are useless for anything except artificial manure, it is put on the market at an extremely low price, that is about £3 15s. per 100 kg. for the opaque quality and £4 15s. for the transparent make. Considering the general utility of the new material its prospects seem very encouraging.

Austria's Monopoly as a Producer of Radium.

The unique position which Austria enjoys as the chief source of radium seems now practically assured as the Government takes active measures in order to strengthen this monopoly. An important step was the recent purchase of two large properties in the famous district of Joachimsthal, which contain uranous uranate $V\ (U\ O_4)2$ The purchase price is said to have been about £80,000. The working of this property promises to result in a considerably increased production of radium. So far only 1·5 gramme of this remarkable element has been produced, but in the near future this amount will probably be increased to 4 grammes. During the current year, the probable production of radium in Austria is estimated at 2·8 grammes, and in a few years' time the country will be able to supply about 4 grammes, which would be sufficient to satisfy the world's demand, unless new purposes for its use are discovered. The value of radium in Austria is at present about £16,666 per gramme.

A New Textile Material.

A new textile material has recently been introduced into this country under the name of "artificial wool." This name is hardly correct, as the material is neither wool nor artificial, being of vegetable origin. A certain resemblance to wool cannot, however, be denied. In curl, length of staple and lustre this new preparation of jute passes easily for wool at a little distance. The colour is a golden brown naturally, but after bleaching the material is like scoured wool in colour. The harshness, brittleness, and sadness of the material proclaim its vegetable origin to the hand. It can be intermixed with wool by carding processes, and blankets made half of "artificial" and half of real wool are barely distinguishable from all-wool blankets. The all-important question of cost is, however, one of the chief factors to be considered. It remains to be seen whether it can compete with woollen waste and shoddy with which the market is so abundantly supplied.

Financial Results of Leading Chemical Firms.

The financial results of some of the leading chemical firms in Germany are of sufficient interest to English chemists to deserve a brief survey. The large South German concern at Ludwigshaven, the Badische Anilin- und Soda-Fabrik, seems to have had a satisfactory year, though the turnover in dyestuffs would have been better but for the high price of raw cotton, which resulted in a curtailed output of manufactured goods. Competition is very keen, and prices of many of the Company's productions have had to be reduced. Their trade in the United States continues to develop satisfactorily. Business with China was brisk until the disturbances broke out. Commercial conditions in Japan are not yet satisfactory. The crop failure in Russia is making business there more difficult than usual. The war with Turkey has had little direct influence on the Company's trade with Italy. The total number of workpeople and officials employed is 7,743 against 7,621 the previous year, and the amount paid in wages 12,36 million marks against 11,92 million marks in 1910. The capital of the undertaking remains at 36 million marks, and the reserve fund now amounts to 22,5 million marks. The net profit for the past year reached 12,387,409 marks, against 10,792,075 marks for the previous year, and the dividend will be maintained at 25%.

The well-known Elberfeld concern, "Farbenfabriken vorm. Friedrich Bayer & Co.," has a net profit of 14,122,036 marks against 13,605,619 marks. This firm, too, proposes to pay a dividend of 25%. The Chemische Fabrik Buckau at Magdeburg are paying 12%, but the Berlin Anilin Company are again able to declare a dividend of 20%. Another flourishing concern is the firm of "Farbwerke vorm. Meister Lucius and Bruning, at Hoechst-on-Main. Their report for the last year discloses a net profit of 16,125,196 marks against 14,221,406 marks. This enables them to raise the dividend from 27% to 30%.

The largest producer of synthetic indigo in Germany is a Dresden firm, the "Von Heyden Chemical Company." This concern is paying 14% against 12% last year.

Potash Salts in Venezuela.

A French Company is arranging to exploit the potash salts which are found in solution in the waters of Lake Urao in Venezuela. These salts have been used locally as a fertilizer for many years, but as the lake is in a very inaccessible region of the Andes, the difficulty in bringing the product to Lake Maracaibo has hitherto been unsurmountable. The new company plans to bring the product by an aerial cable line from the lake to a level where it can be economically handled.

The First Potash Plant in the United States.

A potash-producing plant, the first of its kind, is now in actual operation in the United States. It is located in Southern California, north of San Diego, and operations in the commercial extraction of potash from kelp of seaweed were quite recently begun. The plant is owned by the Colorado Chemical Company, which has been working on the potash-kelp problem for several years. It consists of four furnaces capable of treating 6,000 pounds of dried kelp every 24 hours, and additional furnaces are under construction with a proposed total capacity for treating 36,000 pounds of dried kelp a day. The current year will probably show a substantial output of potash in the United States, in addition, of course, to that obtained from wood ashes.

The potash imports into the United States are shown to have had a value of $16,269,408 in 1911, showing clearly the importance of the article. The Government bureaus have for some time instituted an active search throughout the country for potash, resulting in several discoveries of more or less importance. One of the most recent finds which caused considerable excitement in fertilizer circles, is a deposit located at Searles Lake in California. A conservative estimate places the quantity of available potash at 4,000,000 tons. The great value of the find is that the product is in readily available commercial form. The location is a dried-up lake.

Government scientists as well as private enterprises are leaving nothing undone to make the American consumer of potash independent of foreign producers. How far they will succeed time alone can show.

Utilisation of Mineral Gas for the Production of Nitrogen from Air.

The mineral gas well of Kissármás in Hungary, which was driven to a depth of about a hundred metres, yields almost entirely pure methane. It contains 99% methane, the remainder consisting of hydrogen, oxygen and nitrogen, whereas neither carbonic acid nor carbon oxide are present. It took more than two years of strenuous work before the source of gas could be reached by means of a pipe anchored in a concrete block measuring 5 metres in height. The Hungarian Government, by an Act of Parliament, declared this well, and all others which may be found yet, to be State property, and since then negotiations are proceeding with a view to exploiting this gas, which is permanently under a pressure of 28 Atm. A scheme submitted by the Badische Anilin und Soda-Fabrik aims at the use of this gas in gas-dynamos and the utilisation of the current in a plant working on the Birkeland-Eyde and Schoenherr principle for the production of nitrogen from air. The plant would, with a preliminary capacity of 20,000 h.p., produce annually 9,500 tons of nitrate of potassium and 2,500 tons of nitrate of soda.

According to another project, by a new method of Linde, nitrogen from air could be produced by submitting the methane to a special process of combustion. Proposals have also been made for conducting the gas to the cities for household purposes.

Sulphur Mining in Japan.

Next to the Sicilian product, Japanese sulphur ranks foremost in the world for excellence. As regards quantity, Japan hardly produces more than one-twentieth as much as Italy. But the wide diffusion of the producing districts, and the excellent quality of the Japanese product promise the development of a fine industry. Japanese sulphur is largely demanded on the Pacific slope where it almost monopolizes the market. Sulphur is used there in the manufacture of phosphoric acid, sulphuric acid, wood-pulp, fertilizers, insecticides as well as for the refining of kerosene oil. Australia and the United States are the chief markets.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

27782/10. J. A. STEVENSON, London. *Treatment of Fermentable Substances.* 29 November, 1910.

The invention relates to the treatment of fermentable substances, viz., yeasts of all descriptions, and has for its object the mixing or treatment of such substances in a fluid condition in order to incorporate at once with the fermentable substance any accelerating agent, such, for instance, as sugar or malt extract. The invention consists in placing separately under pressure, which may be hydrostatic or produced by a double pump or by gases, the fermentable substance and the accelerating agent, and delivering them in a proportionate amount into a compressing device adapted to get rid of all the liquid from the compressed substance after the proper compression has taken place, in order that a dry product may be finally obtained, which will contain latent fermentability capable of being brought into action under heat and moisture. (5 claims, 3 Figs.)

28489/10. W. E. W. RICHARDS, London. *Waste Rubber Treatment.* 7 December, 1910.

According to this invention, old, worn or waste rubber may be recovered or/and reformed and used as rubber and, if desired, revulcanised or otherwise employed in any suitable manner; or in the process of recovering such waste rubber, a permanent mixture of another substance or other substances may be formed with such waste rubber, this mixture or composition then being moulded or/and vulcanised. The invention consists in subjecting a mixture of sub-divided waste rubber and asbestos, under stirring action or agitation to such a high temperature (as, for example, about 300°C.) that the waste rubber will be fused or melted and incorporated with the asbestos, after which the mass either (a) has sulphur mixed therewith and the mixture then moulded and vulcanised in the mould, or the mixture may be vulcanised in the mixing machine and then moulded, or (b) the aforesaid mass (without the addition of any sulphur) has a rubber solvent added thereto whereby the rubber is dissolved and separated from the asbestos and thereby recovered. (4 claims.)

5349/11. R. G. EAST, Wimbledon. *Regenerating Rubber.* 3 March, 1911.

The invention consists in a process of regenerating rubber wherein disintegrated rubber is uniformly heated throughout its whole mass, and is then compressed prior to moulding. In the preferred arrangement, the disintegrated rubber is passed through a heated feed chamber wherein it is subjected to agitation and thence to the compressing chamber and mould. The moulding preferably takes place at a temperature higher than it has previously been subjected to during the process of regeneration, and heat may or may not be applied while the rubber is in the compression chamber. The invention further relates to a process for regenerating rubber which consists in (a) heating disintegrated rubber throughout its whole mass, (b) subjecting this heated rubber to pressure, (c) moulding it under a higher temperature than that to which it is raised before compression with or without heating the rubber while it is being compressed. (5 claims, 2 Figs.)

5395/11. J. S. CAMPBELL, Isleworth. *Artificial Rubber.* 3 March, 1911.

According to this invention, a material having the characteristics of rubber is composed of seaweed (with or without other vegetable matter) previously boiled, as distinct from mere washing, in ammonia, to which is added oil, together with a glutinous or resilient binding material and a vulcanising substance, the whole being agitated in a heated condition. (7 claims.)

5396/11. J. S. CAMPBELL, Isleworth. *Artificial Leather.* 3 March, 1911.

According to this invention, a material having the characteristics of leather is composed of seaweed (with or without the addition of other vegetable matter) previously treated by boiling with ammonia to which is added fibrous material, powdered filling material and a glutinous or resilient binder, the whole being agitated in a heated condition, with or without subsequent pressure, and with or without complete or partial vulcanisation. According to one modification, a mineral or vegetable oil is added to the composition, and as a further modification wood or bark extract is also added. (9 claims.)

6165/11. R. DEMUTH, London. *Solidified Petroleum.* 11 March, 1911.

The invention relates to the conversion of paraffin or petroleum oils or spirits into jellies or solids of various degrees of hardness. The general method of solidifying petroleum oils consists in dissolving therein or mixing therewith various soaps or solid fats, with or without the addition of alkalies, to give them the desired consistency. This method involves the use of comparatively large proportions of soaps or fats, which add materially to the cost, and the products liquify at raised temperatures and leave undesirable residues. According to this invention, it is not necessary to use more than a small proportion, for instance, 1 or 2 per cent. of organic binding material to gelatinise or solidify the petroleum oil or spirit. As organic binding material, salt forming nitrogenous substances, of which casein is a type, capable of forming with ammonia thick gelatinous aqueous solutions and with alkaline earths, such as magnesia and lime, solid insoluble masses, are employed. (4 claims.)

12746/11. L. L. T. LABBE, Oisnieres, France. *Celluloid Substitutes.* 26 May, 1911.

The invention relates to the manufacture of a non-flammable substance, which is insoluble in water and intended more particularly for replacing celluloid. Similar products having gelatine and gum lac as a base are known. It has also been proposed to add to similar products with a base of gelatine and dextrin, small quantities of silicate of soda for the purpose of rendering the dextrin in excess insoluble. It has further been proposed to prepare a soluble glue substitute consisting of an alkaline solution of casein, a soluble silicate, and a salt of a metal of the alkaline earth or of the magnesium group. The property of albuminoid solutions of precipitating solutions of silica is utilised, and also the employment of silico-glyceric jelly combined with these collo-silicates. (4 claims.)

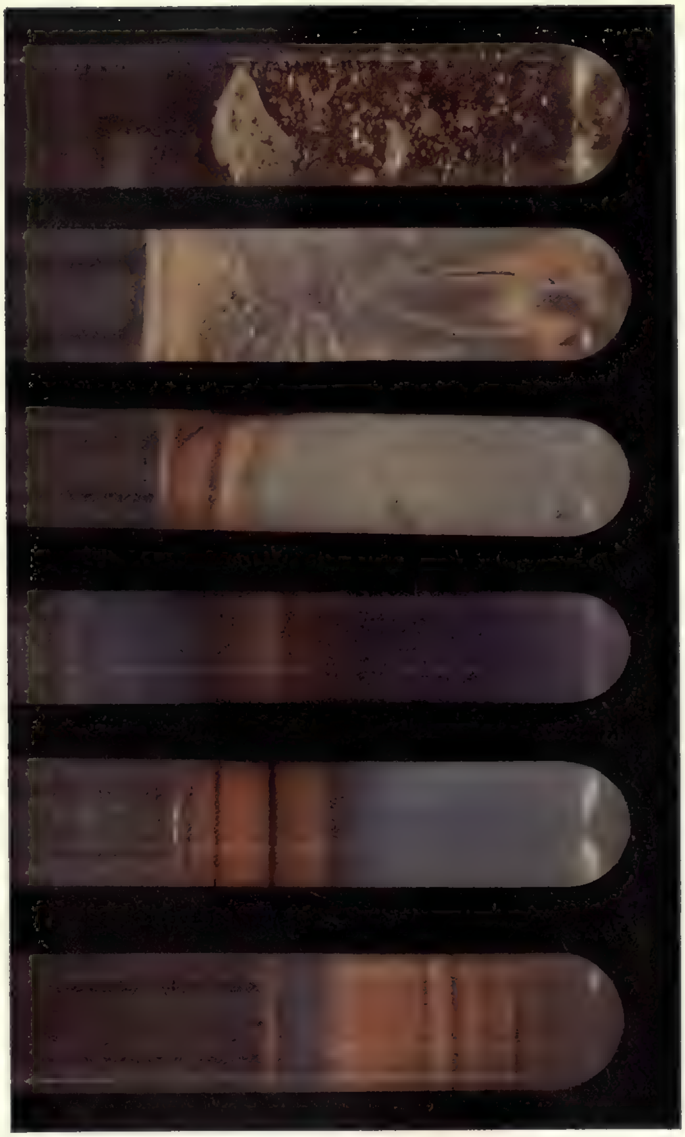


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.

HATSCHEK & SIMON.—Gels in Relation to Ore Deposition.

THE
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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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NON-FERROUS METALS EXHIBITION.

THE fact that an Exhibition dealing with this subject is to be opened on the 17th inst. at the Agricultural Hall is one of the indications of the great advance which has taken place of recent years in the production and manipulation of non-ferrous metals, especially in the form of alloys.

Many of these were in comparatively recent times known as rare metals. Sodium, vanadium, aluminium, calcium and others are now produced on an industrial scale, and have exerted, either directly or indirectly, a great influence on the metal and other industries.

It is only necessary to point to the production of "high speed" tools to realise the great influence which has been exerted on industry by the introduction of these materials in quantity, and at prices at which they can be directly utilised as raw materials in commerce. The metallic filament lamp industry is one of the results of this new development, and is especially interesting in view of recent modifications in the methods used when working with these refractory metals.

With this advance has come a greater knowledge of the internal and external structure of metals; and this has in its turn reacted on the principles of general chemistry, and thrown further light on molecular and crystalline structure. We are faced with developments which certainly bid fair to still further modify and extend theoretical knowledge, and facilitate practical working conditions to a degree.

Closely connected with this change in modern industry is the rapidly extending use of the electric furnace, coupled with the production of cheap power. The advent of Autogenous welding has also played a part in this development, especially in the case of aluminium, and such processes as those of Martin, or Simpson, for joining non-ferrous metals to iron or steel may also in time modify the use of both these materials. The Sherardising method of galvanising is also another case where possibly development of a far reaching nature may be expected, especially when considered in conjunction with the recent work on the altered physical properties of metals *in vacua*, and their increased tendency to volatilise under such conditions.

The indirect uses to which some of these metals are put is an interesting feature. For example, aluminium is to be used as a raw material for the production of aluminium nitride, and through this the production of ammonia from the air. This, and the manufacture of sodium cyanide from sodium, may be instanced as examples illustrating this side of the general development. It is a feature of such processes that when once started they come into extended use.

This rapid extension of knowledge and practice in the metal world in the direction of the non-ferrous metals is well reflected in the success of the recently formed Institute of Metals, and the great importance of the work which is being done in this country on the theoretical side by such workers as Beilby, Detsch, Rosenhain, Turner, Carpenter, and many others. This is certainly an important factor in the general development.

The recent address by the President of this Institute was a brilliant record of the revolution which has taken place in the methods of research adopted during recent years in this industry.

The Exhibition is under the Presidency of Sir Gerard Muntz, and the Advisory Council includes many names which are household words in the world of metals. This venture cannot fail to give those interested in this industry a more complete knowledge of the general development which has taken place on the industrial side, and at the same time supply those who are working on the more scientific side of the subject with an additional incentive to further activity, especially as empirical methods can play but a small part in these modern developments, which are destined to control future manufacturing conditions.

A Wandering Industry.

It is evident that Ceylon has lost the interest it at one time possessed in cinchona bark, for possibly the same reason that India is destined to ultimately lose the indigo industry. In the two seasons 1885-6 and 1886-7, during which time the Island shipped 30,000,000 lbs. of bark, the price of quinine was 16*s*. oz. When the price had fallen to one-tenth of this figure, planters found that tea became a more profitable product, and the cultivation of the former gradually decreased, until in 1910, only 80,000 lbs. of bark were exported, and *now only nine acres are cultivated in the whole Island*.

The trade has passed to Java. This Dutch Island is practically supplying the world's production of this essential raw material.

The Preanger Regencies Residency in Java has proved itself to be the district *par excellence* for the cultivation of cinchona, and the percentage of quinine obtained from the bark of trees grown there is far higher than elsewhere, and is increasing. The greater the percentage of quinine the bark contains the more certain the cultivation, and as Java has made the industry so profitable and can supply the world's requirements, it is evident that Ceylon might find insuperable difficulties in recovering this trade if she ever desired to do so. Java may always hold her own against other producing countries, owing to soil and favourable climatic conditions. The various South American countries have lost all importance as bark-producing countries.

An interesting indication of the way in which the trade has passed into Dutch hands is the fact that whereas formerly London, Hamburg and New York were large markets, Amsterdam now practically monopolises this trade, and bark sales take place there regularly. A small trade, however, is still conducted in London. The world's production of quinine exceeds 17,000,000 ozs. per annum, which is consumed annually. The consumption is increasing.

The cinchona tree was originally found in South America, and there is no doubt that it is the most valuable medicinal bark known. Originally the tree grew only in the areas of Bolivia, Peru, Ecuador, Colombia, and Venezuela. It is generally believed that the bark was named after the Countess of Cinchon, or Chincon, wife of a Spanish Viceroy of Peru, who was cured of fever by its aid in 1638, and who introduced it to Europe on her return. Towards the middle of the nineteenth century, owing to ruthless gathering and the lack of protection by the South American Governments, the product became scarce. Botanists visited South America, with the support of their Governments. The result was the introduction of the cinchona plant into the tropical Asiatic countries, India, Ceylon and Java. From the date of its introduction the cultivation of the tree prospered.

In India the fever mortality for 1908 was five and a half millions, practically the population of London, and malaria is the most prevalent fever in India. This condition has been met by the distribution of quinine, gratis and otherwise, by the Government.

In distributing this substance at a low price, the Italian Government has also brought about the distribution of quinine prepared by the State. The moral and social result of this and other precautions has been the diminution of the mortality from malaria from 15,865 in 1900 to 3,463 in 1908, on a population of about 35,000,000. In Greece, quinine is also distributed by the Government as a malaria prophylactic. As in Italy, great success has attended this movement.

Thus history records a case of a transported industry which by steps has seemingly reached its industrial home. The original districts, and the intermediate one (Ceylon), can now be practically neglected as factors in the commercial position. South America may one day be treated in the same way, so far as rubber is concerned, if local opinion is not roused sufficiently to deal with production under scientific conditions, as practised in the case of Java, and the cinchona industry.

Home Grown Tobacco and Sugar.

Recent results in tobacco growing in Ireland have given results which may be regarded as encouraging. It is interesting to note that Government aid is given in the shape of a 14% rebate on duty in Ireland, while a 33% one is offered in this country. The tobacco can be delivered at the Dublin factory at a cost of 4*d*. per lb. The duty then raises it to 3*s*. 10*d*. The market value on an acre under cultivation in Ireland has been estimated at £25. This compares with about £15 at the Cape. The gross value of tobacco in Ireland is £300 per acre in some cases, of which sum the Government takes £262 10*s*. 0*d*. The Development Commission have decided to make a grant of £7,500 per annum for 10 years to encourage tobacco growing, subject to at least 300 acres being grown. This seems a very high figure, but it must be remembered that the Treasury would probably receive £78,000 in revenue from the same crop.

Turning to beet-sugar, about 3,500 acres have actually been sown in Norfolk this spring, and a factory to deal with the crop produced is rapidly nearing completion. It is even proposed to erect two other factories in the East Anglian district under the same management, which has had great experience in Holland. The principles of intensive cultivation will be hastened in this country by this step, and similar ventures are being considered in Cornwall and at Kidderminster.

Perhaps the fullest information yet published in this country concerning the nature of the factories on the Continent was recently given in this Journal.

We propose to deal further with the chemistry of the subject in an early number.

This matter is certainly receiving great attention, and success in this direction may influence the general condition of agriculture in this country.

The combination of intensive agriculture, and local factory development, may do much to secure an improved position in many districts.

PROGRESS IN THE METALLURGY OF THE NON-FERROUS METALS.

By GEORGE T. HOLLOWAY.

ALTHOUGH in many respects widely different from that of iron and steel, the metallurgy of metals other than iron, commonly known as the non-ferrous metals, is very intimately connected with the iron and steel trades. Non-ferrous metals, such as manganese, nickel, chromium, tungsten and, more recently, vanadium, molybdenum, tantalum, titanium, and others of the so-called "rare metals," are employed in the production of special steels to an increasing extent which has revolutionised certain departments of the mining and metallurgical industries, and has resulted in the working of deposits previously valueless, or in the conversion of a small into a large profit.

The separation of tin ore from wolfram, the source of most of the tungsten of commerce, by the electro-magnetic separator, and the use of the electro-static method of separating minerals, both now employed on a large and increasing scale, are especially important.

The enormous increase in the working of alluvial deposits for tin, gold, platinum, monazite, etc., has resulted in the recovery of large quantities of heavy minerals other than those actually sought, but of considerable potential value. Even now, large quantities of these by-products, as obtained during the final concentration of the original rough concentrate from dredging or hydraulicing operations, are thrown away without their existence being suspected. The amount of the fine-grained valuable material thus discarded, although the bulk of the labour necessary for their conservation had been done, is incalculable. It is true that, in a few cases, such by-products are set aside for possible future treatment, but this refers mainly to the coarser and more easily recovered material, as practically all the finer particles are washed away and probably lost for ever.

As the alluvial deposits yielding the heavy precious metals, or tin, tungsten and monazite, are mainly derived from the denudation of the oldest plutonic rocks, in which nature originally produced the larger proportion of the minerals containing the rare heavy metals and the rare earths and rare alkaline-earthy minerals, they form practically the only source from which large supplies of these elements can be expected. Magnetite, titaniferous iron ore, rutile, sphene, topaz, zircon, garnet, tantalite, columbite, monazite, wolfram, pitchblende, molybdenite, and many other minerals of considerable value could be obtained in large quantities from these alluvials, and the fact that the demand will certainly increase, when the existence of regular supplies is recognised, encourages the hope that the present unpardonable waste will cease in the near future.

The value of these rare metals consists in many cases in their extraordinary power of improving the quality of steel for special purposes, and their production in powdered form or as alloys, has given an impetus to research as to their properties, which bids fair to result in the use of certain of them for special technical purposes, to which no other metals are applicable. Already tantalum and tungsten, prepared by the electric furnace process by metallurgically simple, but actually expensive and roundabout methods, in a condition of great purity and free from carbon, are being worked into wire for electric filaments. Although over 25,000 25-candle power lamps can be made from a quantity of wire weighing under 1 lb., so that the total annual use of either in lamp manufacture is scarcely even measured by hundredweights, the industry is an extremely important one, and, in the case of tantalum at any rate, is likely to develop into a large consumption of the metal for laboratory appliances, surgical, dental and physical apparatus. It possesses an extraordinary combination of toughness and hardness, the former greater than that of steel, and the latter so great that the diamond drill makes but little impression on a sheet which has been superficially oxidised, and that tantalum is employed successfully for pen nibs, in place of those tipped with iridium.

Its power of resisting the action of alkaline solutions and of all acids except hydrofluoric acid—even aqua regia having no solvent action—and of being unacted upon by animal secretions, and non-rusting, is leading to an increasing, though at present, small demand, for laboratory, surgical and dental purposes. The present price of such appliances will be largely reduced, and the fact that the supply of minerals containing tantalum is far in advance of the demand, leaves no room for fear of difficulty in obtaining a plentiful supply of the metal.

The importance of a new use for a metal is, perhaps, even better shown in the case of tungsten. In a bulletin issued last year by the U.S. Geological Survey, it is estimated that the use of tungsten filament lamps results in a saving of nearly £5,000,000 annually in electric power, and that the use of tungsten steel for lathe tools, etc., saves a still larger amount annually in the United States alone.

The above remarks apply mainly to what many may regard as side issues, but the question of the utilisation of by-products is the one on which the future of both ferrous and non-ferrous metallurgy depends. The days of phenomenally rich deposits are not over, but discoveries of such are becoming increasingly rare, and the largest profits are now made on ores which, twenty years ago, were unworkable. Such is the case with all the base metals, and copper may be taken as an example.

The production of copper, now between three-quarters of a million and a million tons per annum, is largely due to the smelting of low grade ores, some containing as little as 1½% of copper, which previously lay idle. The by-products on which the possibility of working them largely depends, are mainly gold and silver, which become concentrated in the metal, and are obtained in the anode mud from the electrolytic purification now carried out on the bulk of the world's production. Not only are the precious metals, which are often merely present in traces in the ore, thus recovered at an extremely small cost, but the bulk of the world's supply of selenium is contained in them. This selenium, although present in such a minute proportion in the original ore that analysis almost fails to find it, becomes concentrated in the copper, and forms a large percentage of the "mud" left during its final purification.

One more reference to the value of by-products may perhaps be permitted in connection with the nickel ores of Sudbury in Ontario, from which considerable quantities of palladium, for dental purposes, as well as of platinum, rhodium, etc., are now obtained. These rare metals occur in such small proportions as to be valueless, except as by-products, but become concentrated in the nickel-matter obtained during the smelting. In 1910, over 2,000 ounces of the platinum metals, mainly palladium, were produced from this source.

The Sudbury nickel deposits are of considerable interest as they furnish the larger proportion of the nickel of commerce, including that produced by the Mond process, from nickel-carbonyl, and as they are the source of the well-known alloy "Monel metal." Originally prepared in the expectation of obtaining an ordinary pig of nickel-copper alloy suitable for general use, by the direct smelting of the crude ore, it has now developed into an important industry, and the alloy, although still a "natural alloy," *i.e.*, one produced direct from the ore, is produced of regular composition and with properties which permit of forging, soldering, electric welding, etc., and of a tensile strength and general qualities which have led to its recognition in specifications for propellers, etc., for the U.S. Navy, and many public corporations. It contains approximately 67% nickel, 27% copper and 6% of iron, manganese and other metals present in the original ore.

The production of metals and alloys in the electric furnace is by no means confined to the rarer metals, and appears likely to extend even to tin, zinc and lead, in addition to its large and increasing use in steel making. The high temperatures obtainable and their perfect control, and the fact that the heat is not produced by combustion of fuel in contact with the material, permit the treatment of materials otherwise difficult to reduce and the production of metal free from carbon and slag.

The reduction of metals of the cerium group from the residues obtained during the treatment of monazite in the preparation of thoria for the incandescent gas-mantle trade, may be mentioned as an important future use of the rare earth metals in connection with the production of pyrophoric alloys for automatic gas-lighters, etc.

The production of metallic calcium can now be cheaply carried on in the electric furnace, and may ultimately find considerable development for use as a de-oxidizer for metals and alloys, while the production of "metallic" silicon or "silicium" and silicon alloys, already constitutes a large industrial enterprise in connection with both the ferrous and non-ferrous metals. The enormous recent increase in the use of titanium steel for rails is of especial interest in connection with the employment of metals which exist in nature in large quantities, but, until within the last generation, have been practically unemployed. Titanium increases the wearing qualities of rail steel by improving its homogeneity, and appears to owe its value mainly to its power of removing nitrogen and increasing the fluidity of the metal so that slag is more effectively expelled. Titanium has much the same power as aluminium in the latter respect, and is largely replacing it in the steel industry. It is interesting to note that titanium steel is not a titanium alloy, as the metal is employed merely as a refining agent and is removed in the slag.

Although the present method of producing aluminium in the electric furnace, or rather, by the electrolysis of fused aluminium compounds, does not appear to be capable of much improvement or reduction in costs, the use of the Baeyer process of making alumina has indirectly reduced the cost, and has permitted the use of highly ferruginous bauxite formerly not capable of employment in aluminium manufacture. The competition induced by the lapsing of patents has resulted in a reduction in price which provides a regular supply at a cost which permits its employment for the innumerable uses to which it is applicable. The early difficulties due to liability to corrosion have been largely overcome through increase in the purity of the commercial metal, and although a reliable solder is still wanting, the introduction of Autogenous welding has led to the employment of large aluminium vessels in brewing and in a number of other important industries.

One of the most important applications of aluminium is for the production of light strong alloys for motor-car, aeroplane and other work. So many of these have been invented and so many different metals used, and processes of preparation employed, that no description of them is possible in this article, but the alloy known as "duralumin" may be mentioned as typical. While having a specific gravity of only 2·8, it has about three times the hardness of aluminium and a high tensile strength and elongation.

Apart from direct metallurgical advances, probably the most important development during the last decade has been the increase in metallographic and other physical tests for metals and alloys.

The Institute of Metals was not explicitly founded in connection with such work, but one cannot fail, in reading its transactions, to note the great preponderance of physical over essentially metallurgical or chemical research. Although one is apt to regret the existence of so many independent societies, specialisation may render their formation necessary, and no better justification could be found than in the work of the members of the Institute of Metals. Although chemical analysis and rule-of-thumb methods of testing will always be essential, they may now be regarded as parts of a wider scheme of testing and, in some respects, as of less importance than carefully conducted physical investigations.

The recent coal strike has given rise to further consideration of the relative advantages of coal and other fuels, and may be expected to result in economies even greater than have been obtained during the last decade through the conservation of water energy and the utilisation of waste heat. The employment of furnace gases, producer gas, etc., in internal combustion engines, and the use of oil fuel, either in the form of gasolene, petrol or other petroleum products, or of crude petroleum and other oils in engines and for direct firing, are leading to considerable improvements in metallurgical work and in reduction of cost.

At the Royal Mint, after a comprehensive series of tests with electric, oil and other furnaces, the old coke furnaces for bullion have been replaced by furnaces fired with town gas at ordinary pressure with air at 2*d.* lb. Crucibles now stand 18 heats at a cost of 4¼*d.* per cwt. of standard gold bullion, as against 12 heats at a cost of 7*d.* with coke firing. In Birmingham, gas at high pressure is coming into general use, and it is stated that, in brass melting, pots will stand 30 heats at 3·75*d.* per 100 lb. of metal as against 24 heats at 4·7*d.* per 100 lb., saving in time, reduction of loss, improvement in product, and cleanliness, being further advantages.

In the direct smelting of ores, oil fuel is now largely employed, especially in America. At Cananea, which is nearer to oil than coal, and at Steptoe, Nevada, about midway between oil and coal, oil is employed as fuel for copper smelting in reverberatory furnaces, and on account of the success already achieved at Steptoe, furnaces for Californian crude oil are being erected at Garfield, Utah.

As regards the use of oil fuel, at any rate in countries to which it has to be transported, it must not be forgotten that within the last two years crude oil has risen in price by about 50%, and that as the supply is small in comparison with coal, the cost will be further increased with even a small rise in the demand.

THE NITROGEN CYCLE IN THE SOIL.

By E. J. Russell, D.Sc.

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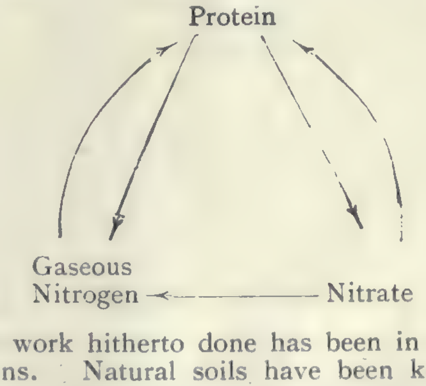
The characteristic of soil that distinguishes it in its natural state from a sand heap or a clay bed is its covering of vegetation. Whilst the plants are alive they synthesise complex substances, such as starch, cellulose, protein, etc., containing considerable quantities of stored up energy derived from sunlight. When they die their leaves and stems fall on to the soil and mingle with it, thus effecting the addition to the soil of unstable organic substances, and consequently of sources of energy, from which the very varied microscopic population of the soil can draw its sustenance. So far as is known, oxidation of soil organic matter affords the chief source of energy for the numerous micro-organisms, and in soils where oxidation proceeds only slowly, as in certain moorland soils, there is a corresponding diminution in the micro-organic population.

This oxidation process has been studied in some detail in so far as the change in nitrogen content is concerned. It has been found that the protein contained in the plant residues may decompose with the ultimate evolution of gaseous nitrogen. On the other hand it has also been shown that gaseous nitrogen may be assimilated by certain bacteria with formation of protein. Or, again, the protein may decompose and give rise ultimately to nitrates which, in turn, under certain conditions may break down and evolve gaseous nitrogen, or they may be assimilated by plants and built up into protein. Thus a cycle can be recognised in which gaseous nitrogen and protein both take part, and to it the name "nitrogen cycle" is commonly applied:—



The work hitherto done has been in two chief directions. Natural soils have been kept under observation for a number of years, and the changes in nitrogen content or in nitrates have been measured. Experiments have been conducted in the laboratory to try and disentangle the processes taking place, or to try and reproduce them. In spite of many efforts the work is far from complete, but sufficient has been done to show the extraordinary interest of the problems involved.

When an arable loam—which is perhaps as close an approximation as one can get to the ideal average soil—is kept moist, aerated and at 10°—15°C., these being normal conditions, there is a slow but steady formation of nitrate, about 3% of the total nitrogen being converted each year. How far the accumulation of nitrate would go under these circumstances has never been ascertained, because the experiment is necessarily very slow. Boussingault records that he kept a soil for eleven years and found that one-third of the nitrogen had changed to nitrate, but this experiment does not appear to have been repeated. Under natural conditions the rate of conversion is certainly much slower.

The nitrates can only accumulate in the soil in absence of vegetation and of rain. Plants assimilate them rapidly and change them back into protein, thus completing the cycle. Rain washes them out from the soil. Thus a soil that is being cropped tends to lose nitrogen, some being removed in the crop, some being washed out as nitrates by rain during the periods when the land is lying bare, and some apparently going off as gas, especially on rich soils.

On the other hand soil that is covered with vegetation which is not removed, but is allowed to die and fall back on to the earth, steadily gains in nitrogen. A piece of land at Rothamsted contained 0·108 per cent. of nitrogen in 1881, it was left to itself and allowed to become covered with the miscellaneous assortment of weeds and grasses that spring up under these conditions, nothing whatever was added and nothing taken away, and in 1904 it contained ·145 per cent.

These are the general facts revealed by a study of soils in their natural conditions: it remains to consider the results of the laboratory experiments that have been made to trace out the changes. The production of nitrate from complex-nitrogen compounds is known to take place in at least three stages: ammonia being the first product, a nitrite the second, and a nitrate the third. No sufficient investigation has been made of the formation of ammonia in soils. The old view was that the plant residues decomposed to form "humus" and this broke down to form ammonia. But "humus" is now known to be an indefinite mixture of substances, and this old view is no longer helpful, but the reverse, in investigating the problem. It is more probable that the protein hydrolyses in the usual way, giving rise to ammonia and amino-acids, the latter further decomposing to form ammonia.

Whatever the process the production of ammonia is largely bacterial, but not entirely, because it still goes on in presence of 4% of toluene. It is slowest of the three stages in nitrification, and therefore is of very great practical interest, because it limits the speed of the other two stages. One of the great problems of the soil chemist is to increase the rate at which ammonia production goes on, so as to be able to accelerate nitrification in the soil.

The second stage, the formation of nitrite, is exclusively bacterial, and has been studied more fully because it lends itself fairly readily to laboratory work. In principle, at any rate, the investigation is simple: it is only necessary to take pure ammonium sulphate, calcium carbonate, and the necessary nutrient salts (potassium phosphate, etc.), together with a pure culture of the organism; there is no need to work with complex unknown materials like soil organic matter. The conversion of ammonia into nitrite is practically quantitative and so far as is known it takes place in one step; no intermediate product has yet been detected, hydroxylamine has been looked for but not found, and there is no evidence of the intervention of an oxidase. Further, the action is specific: only one organism is known to effect it, and only one compound, ammonium carbonate, can be acted upon, all other ammonium salts, urea, the substituted ammonias, etc., being unaffected. The last stage, the oxidation of the nitrite, is also bacterial and is specific to one organism.

Turning now to the other side of the cycle, the evolution of gaseous nitrogen during the decomposition of protein is a bacterial process, but is practically uninvestigated. The action requires the presence of considerable quantities of easily decomposable organic matter (*e.g.*, plant remains) and of oxygen. It goes on to an alarming extent when virgin soil is first brought into cultivation, and is perhaps the chief factor in the rapid impoverishment of the soil of new countries. It is equally important in old countries wherever intense cultivation prevails, and greatly reduces the returns per unit of added nitrogen for large dressings of manure. The evolution of gaseous nitrogen from nitrates has been much investigated by the sewage chemists but appears to be quite a different action. It is anaerobic and does not seem to proceed to any extent in normally aerated soils.

The other problem, the conversion of gaseous nitrogen into protein, has probably been the subject of more papers in recent years than any other branch of agricultural science. That some recuperative agency must exist to make good the losses of nitrogen from the soil has long been recognised; indeed, thirty years ago a systematic search was begun by Berthelot. Two agencies are now known: the bacteria associated with the leguminosæ which operate within the nodules on the roots of the plant, and certain bacteria, particularly azotobacter and clostridium pasteurianum, that operate in the soil. Of the latter group azotobacter is the most potent, and has therefore received most attention. It requires the presence of easily decomposable organic matter, calcium carbonate and oxygen. Its action may readily be demonstrated by adding 0·1 to 0·2 grams of ordinary arable or garden soil to 100 c.c. of tap water containing 2% of mannitol, ·02% K_2HPO_4 and sufficient calcium carbonate, and keeping for some weeks at 27° to 30°C. in a thin well aerated layer in an

Erlenmeyer flask plugged with cotton wool. The sugar rapidly decomposes and gives rise to carbon dioxide and other products not investigated, but after a time the solution is found to contain complex nitrogen compounds, about ·01 gram of nitrogen being "fixed" for each gram of sugar decomposed. This extraordinary action is established beyond any doubt and deserves serious attention from the organic chemist; as a stupendous synthesis it is probably unequalled. Soil chemists and bacteriologists have been interested mainly in finding out the conditions under which it takes place and how it may be accelerated in the soil, and the experiments have revealed a certain parallelism which, however, may only be accidental, between nitrogen fixation and nitrogen evolution from protein. Both require oxygen and ample supplies of easily oxidisable organic matter, and it is not *à priori* easy to say which is likely to go on in a given case.

Thus the laboratory experiments indicate that most of the reactions in the nitrogen cycle are bacterial, and hence it is inferred that most of the similar changes going on in the soil are bacterial also. The direct evidence in favour of this view is only slight, but no alternative hypothesis has ever found general favour.

OPTICALLY ACTIVE COMPOUNDS OF COBALT AND CHROMIUM.

By E. JOBLING, B.Sc., A.R.C.S.

To the student of stereo-chemistry, the last few years have been fraught with interest. The extension of our ideas upon asymmetry to the nitrogen atom, and then in quick succession to sulphur, selenium and tin, marked a notable advance, the importance of which, particularly in its bearing upon our knowledge of the internal forces of the atom, it is difficult to over-exaggerate. Last year, again, phosphorus was added to the list, and now we have to record the discovery by Werner of a remarkable series of optically active compounds of cobalt and chromium, whose activity can be traced, in this case, to the *hexa*valency of the elements in question. These astonishing results not only provide a far-reaching extension to our stereo-chemical ideas, but form what may be regarded as a fitting consummation to the theory of the structure of molecular complexes, at which the same investigator has been working for many years.

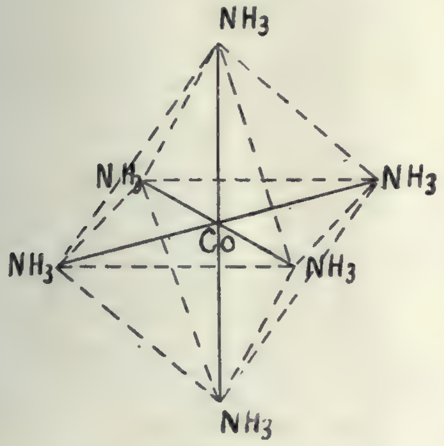
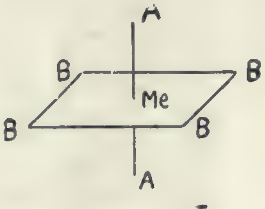


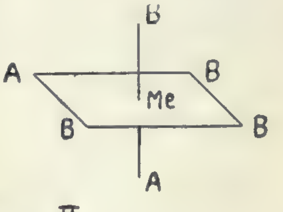
FIG. *a*.

In order to understand the experimental evidence, a brief outline of this theory is necessary. An element is regarded as possessing, in addition to its usual or "principal" valencies, what Werner designates as "auxiliary" valencies, *i.e.*, a kind of fractional valency capable of effecting the union of otherwise independently-acting molecules like NH_3 and H_2O. For the present purpose, it will be convenient to distinguish between these two types of valency, though the manifestation of the latter is understood by Werner to be independent of units, being variable within wide limits with the nature of the atoms combined and the external physical conditions. Under the influence of both principal and auxiliary valencies, the components of a complex molecular compound arrange themselves into zones around the central element. The first zone comprises a maximum of four or six univalent atoms or groups, this number going by the name of "co-ordination number," and each additional component of the complex is relegated to the second zone, where it naturally takes upon itself certain peculiarities in behaviour, notably that of mobility and consequent tendency to ionisation.

Let us take as example the well-known complex $Co\,Cl_2\ .\ 6NH_3$. Formerly the structure of this was written
$Cl\ .\ NH_3\ .\ NH_3\ .\ NH_3\ .\ Co\ .\ NH_3\ .\ NH_3\ .\ NH_3\ .\ Cl$, a representation at once unwieldy and inadequate, though consistent with the then-prevalent ideas of valency. Werner, however, regards it as possessing the structure shown, $\left[\begin{matrix} NH_3 & & NH_3 \\ NH_3 & Co & NH_3 \\ NH_3 & & NH_3 \end{matrix}\right] Cl_2$ in which the ammonia molecules are united with the cobalt atom by auxiliary valencies and comprise the first zone (usually marked by square brackets), (Fig. *a*) whilst the two ionisable chlorine atoms fall into the second. The elegance of such a configuration lies chiefly in its three-dimensional

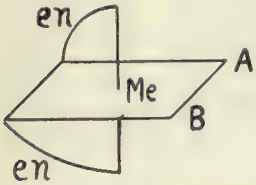


I



II

representation, for the six constituents of the first zone may be supposed arranged symmetrically around the metallic atom, so as to be situated at the corners of a regular octahedron. We have then, in our example, a representation which is indicated, where the cobalt atom finds place at the centre, the position of the two chlorine atoms, by reason of their ready separability remaining undefined. Of course, other groups than NH_3 may be included in the first zone, in which case it is easy to see that circumstances might arise when isomerism becomes possible. This is so with compounds represented generally as $\left[\mathrm{Me}\,\begin{smallmatrix}A_4\\B_2\end{smallmatrix}\right]X_n$, for the compounds I. and II. are structurally different. This important deduction it has been possible to prove experimentally in the case of several elements.



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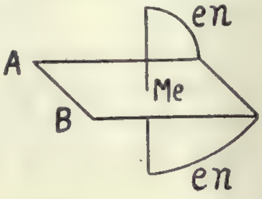
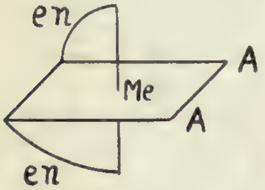


IV

Furthermore, from this hypothesis of the tetrahedral grouping, one can predict the possibility of two isomers, whose space formulæ are non-superposable and which should therefore each exhibit the phenomenon of optical activity. A glance at the structures III. and IV. or at V. and VI. (in which en = ethylene diamine and is therefore equivalent to two molecules of NH_3) is sufficient to show that these compounds are strictly enantiomorphous. Indeed, compounds III. and IV. contain an asymmetric metallic atom, for there are two tetrahedra present, each with four different groups (Me, A, B, en) at its apices. With V. and VI., however, this does not apply, so that we are face to face here with a kind of molecular asymmetry, which should also be concomitant with optical activity. By submitting to resolution certain compounds of the two types $\left[\begin{smallmatrix}A\\B\end{smallmatrix}\,\mathrm{Co\,en_2}\right]$ and $\left[\begin{smallmatrix}A_2\ \mathrm{Co\,en_2}\\ \mathrm{(Cr)}\end{smallmatrix}\right]$, Werner has actually verified experimentally these theoretical deductions and so placed his theory on the highest plane of probability.



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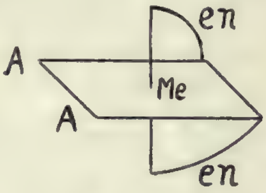
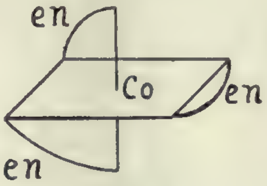


VI

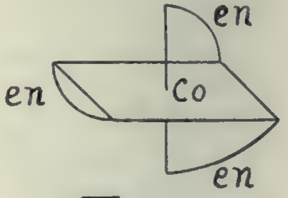
The resolution of the series of compounds represented by the above, in which A or B for the cobalt compounds were Cl, Br, NH_3, NO_2, SCN or H_2O and for the chromium compound A was Cl so far only, was effected by the use of either bromcamphorsulphonic acid or camphorsulphonic acid itself, the former being found to be the most efficient. Usually the silver salt of these acids was made to react with the halogen compound of the racemic mixture and the products then fractionally crystallised in the usual way. Occasionally, the ammonium salt of the active acid was necessary to overcome the difficulty in some cases of decomposition in dilute aqueous solution. The separated isomers have a very appreciable rotation. In the instance of one containing a single atom of cobalt, a specific rotation of 200° was obtained, whilst another with two cobalt atoms gave the quite abnormal value of 840°, corresponding to a molecular rotatory power of nearly 6,000°.

The reactions of these isomers have only been studied as yet in a preliminary kind of way, though what is known is of considerable interest. Thus, while some maintain their optical activity unchanged in solution over several months, others exhibit a phenomenon akin to mutarotation. The substitution of certain components of the complex by different groups is found in some cases to produce racemisation, whilst in others, singularly enough, the activity is preserved. It is interesting, too, to note that a few of these complexes give a very considerable rotatory dispersion. The peculiar feature about the chromium compounds is that the value of the rotatory power always lies about 150° below that of the corresponding cobalt compound, indicating that the metal must play the master-rôle in the production of the activity.(1)

Werner's most recent contribution to this subject consists in the resolution of complexes of the type $[\mathrm{Co\,en_3}]X_2$. His views on the configuration of these compounds point to the possibility of the existence of two enantiomorphs of this class, viz., VII. and VIII. On putting this deduction to the test of the laboratory, it has received complete verification.



VII



VIII

Experimental evidence like this records a triumph to Werner, and should do much to remove the prejudice which exists in England against his ideas. It is only fair to add, too, that a theory, admitting of such harmonious correlation of theory and practice, cannot afford to be ignored, even though it strike hard at our conservatism, but deserves our very careful consideration. In conclusion, therefore, attention is directed to the book, "New Ideas on Inorganic Chemistry" (translated by Hedley), in which Werner fully states the evidence, so far as could be produced at the time, in favour of his theory.

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(1) Most recently, Iron has been found to exhibit the same remarkable behaviour in this respect as both Cobalt and Chromium.

GELS IN RELATION TO ORE DEPOSITION.

By E. HATSCHEK and A. L. SIMON.[1]

THE fact that dissolved substances diffused into and out of gels, such as gelatine or silicic acid gels, was known already to Thomas Graham, who made use of it in the determination of diffusion co-efficients. It has also been known for a considerable time that if such solutions are capable of reacting with substances contained in the gel, the reactions proceed, though with greatly diminished velocity; dry plate photography, for instance, is made possible by the various reactions which take place in the gelatine gel between the developing, fixing, toning, etc., solutions, and the silver salts and reduced silver.

With a suitable arrangement of the reacting phases, a very striking phenomenon is observed, which was first discovered by R. E. Liesegang in 1896, and is generally called after him. Liesegang placed a drop of silver nitrate solution on a film of gelatine containing potassium bichromate. The silver salt diffused into the film and reacted with the bichromate; the silver bichromate formed did not, as might be expected, form a continuous zone or halo round the original drop, but appeared in concentric rings, separated by apparently clear spaces of increasing width. The phenomenon has been studied since its discovery by a number of other investigators, including H. Bechhold,[1] Bechhold and Ziegler,[2] and E. Hatschek,[3] to begin with, in gelatine and agar gels. The arrangement used in all these investigations differs slightly from that of the original experiment, inasmuch as the gel containing one of the reacting components is placed in the lower part of a test tube, and the other component, in aqueous solution, is poured on top of the gel. While the earlier researches were confined practically to the original—silver bichromate—reaction, and a few other silver salts, Hatschek studied a large number of insoluble compounds, including the most important—calcium, barium, strontium and lead compounds—and also undertook a systematic microscopic investigation of the precipitates. This showed, as the most important and uniform feature of all the experiments, that the precipitates appeared in crystals of very considerably larger size than could be obtained by carrying out the reaction in aqueous solutions, that there was a marked tendency to the formation of twins and aggregates approaching more and more nearly spherical form, and, in some special cases, of perfect spherulites.

The concentric rings discovered by Liesegang had already been suggested by him as an explanation of the structure and formation of agates, which, according to his theory, were produced by the diffusion of iron salts into a silicic acid gel. It appeared probable that such reactions might also account for the formation of large crystals or aggregates of minerals, which, on one hand, are very insoluble and show no stalactitic structure, and yet could not very well be of igneous origin. It appeared desirable to carry out further researches in this direction by producing the reactions, not in organic gels as hitherto used, but in the inorganic gel in which they might conceivably have taken place, viz., the silicic acid gel. A series of such experiments—the technique of which is very simple and will be described further on—was therefore carried out by Hatschek,[4] and the results are even more striking than those previously obtained, as macroscopic aggregates of most substances, such as lead chloride, lead sulphate, calcium sulphate, calcium phosphate, etc., were formed. A further feature of great importance from the geological point of view was also brought out by several of these experiments: that large crystals or aggregates could be obtained, not only in the gel, but at the surface of it, in the aqueous solution. To produce the reaction in the gel it is necessary (as had already been found by one of the earliest observers, Pringsheim,[5]) that the solution should be hypertonic towards the gel. If, *e.g.*, the aqueous solution is one of sodium sulphate, and the gel contains calcium chloride, the concentration of the latter must be less than one mol for each mol of the former.

The molecular weights being $CaCl_2 = 111$, and $Na_2SO_4 = 142$, it follows that, for every 111 parts of anhydrous $CaCl_2$ per litre of gel, the aqueous solution must contain more than 142 parts of anhydrous Na_2SO_4 if the reaction is to take place in the gel. If, as is usually the case, crystallized and not anhydrous salts are used, the water of crystallization has, of course, to be taken into account: calcium chloride crystallizes with 6, and sodium sulphate with 10 molecules of water, and the figures for equimolecular solutions become 219 of the former and 322 of the latter.

If the aqueous solution, instead of being hypertonic towards the gel, is hypotonic, *i.e.*, has a lower molar concentration, the reaction does not occur in the gel at all. In that case the salt contained in the latter diffuses slowly into the aqueous solution and reacts there, still, however, forming very much larger crystals than can be obtained by mixing two solutions.

On reviewing these experiments, it appeared probable that many features of the occurrence of gold in quartz could be explained on the assumption that they originated in the reduction of gold salts in a medium of gelatinous silicic acid. Accordingly, an extensive series of experiments on the reduction of gold chloride in silicic acid gels was undertaken by the authors. In one group of these silicic acid purified by dialysis was employed, which was prepared in the usual way, viz.: a 15—20% solution of sodium silicate was decomposed by hydrochloric acid and then dialysed against water. After removal of the excess acid and sodium chloride, the silicic acid solution was filled into test tubes to about half their height, mixed with one to two cc. of 1% gold chloride solution, and allowed to set to a jelly. In another set of experiments dialysis was dispensed with, and the mixture of silicate and acid, with the addition of gold chloride, placed directly in the test tubes, where it sets rapidly.

When the gel had formed, a solution of a reducing agent was poured on top, or the test tube placed in a large vessel containing a reducing gas. The latter is rapidly absorbed by the moisture in the gel and reacts with the gold chloride just like an aqueous solution. The following reducing agents were tried: (1) in aqueous solution—oxalic acid, ferrous sulphate, formic acid with ammonia, sodium sulphite; (2) gaseous—sulphur dioxide, carbon monoxide, illuminating gas and hydrogen.

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[1] [*Read before the Institution of Mining and Metallurgy, 18th April, 1912.*]

In some cases the reverse arrangement was employed, *i.e.*, the reducing agent was added to the gel, and a gold chloride solution of suitable strength poured on top. The results obtained are tabulated as follows :—

A.—GOLD CHLORIDE IN GEL; AQUEOUS REDUCING AGENT ON TOP.

REDUCING AGENT.	APPEARANCE OF REDUCED GOLD.
1.—Oxalic acid...hypertonic...	Extremely lustrous particles, consisting of triangular and hexagonal plates; tetrahedra, octahedra with alternate faces strongly developed, and dodecahedra; microscopic Figs. 4 and 9. (Heating to about 70°C. is conducive to the formation of larger crystals.) Fig. 5.
2.—Oxalic acid...hypotonic ...	The gold grows out of the gel forming yellow-brown aggregates with occasional metallic lustre due to gold crystals. Fig. 6.
3.—Ferrous sulphate	Reddish-brown precipitate.
4.—Sodium sulphite	Reddish-brown precipitate with many lustrous yellow particles; excellent laminations in many cases. Fig. 1.
5.—Formic acid	Reddish-brown precipitate and blue colloidal gold with reddish surface colour. Fig. 3.

B.—GOLD CHLORIDE IN GEL; GASEOUS REDUCING AGENT.

6.—Sulphur dioxide	Reddish-brown precipitate, numerous well-developed strata in top layer of gel.
7.—Carbon monoxide	Dense reddish-brown precipitate with metallic lustre on surface, then lustrous yellow particles, recalling avanturin in appearance.
8.—Illuminating gas	Reddish-brown precipitate, then narrow black stratum and diffuse reddish turbidity. Fig. 2.

A number of other precipitants were also used, such as graphite, charcoal, bituminous shale and crude petroleum. It was found that gold crystals could readily be obtained with a precipitant or reducing agent not particularly soluble in water, while precipitants easily soluble are liable to produce amorphous precipitates. This is in accordance with what might be expected. The same applies to the gaseous reducing agents of simple composition, such as SO_2 and CO, the former yielding a reddish precipitate, while the latter produces crystals. The action of illuminating gas—being a mixture of hydrogen, carbon monoxide, saturated and unsaturated hydro-carbons—is not quite so simple. Besides the gold, a black substance, probably carbon, is precipitated, which calls to mind the presence of graphite in a number of well-known gold[6] and silver[7] deposits. The most important facts bearing on the genesis of gold deposits are the following :

In a gel consisting of silicic acid in which a gold salt is uniformly distributed, a reducing or precipitating agent has the following effects :

(*a*) If the reducing agent is hypotonic in relation to the salts in the gel the whole of the gold will leave the gel and will deposit in aggregates, probably of crystalline form, at the point or points of contact of the reducing agent with the gel. The gel, through losing part of its soluble gold contents, may cause the reducing agent to become hypertonic, and the gold still remaining in the gel would then be precipitated as per (*b*).[8]

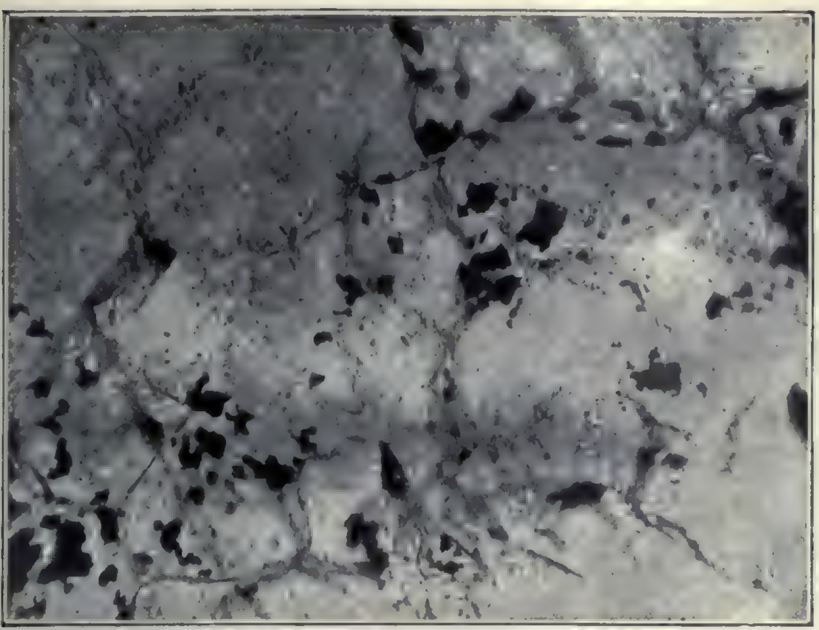
(*b*) If the reducing agent is hypertonic in relation to the salts in the gel the gold will be precipitated within the gel, not, however, necessarily, uniformly throughout the gel, but often in distinct layers, the layers being parallel to the surface of the gel in contact with the precipitating agent, and the distance from one layer to the next one increasing with the distance from this surface.

The above experiments and the deductions therefrom throw some new light on certain gold deposits, and afford a more satisfactory explanation of their genesis than has been suggested hitherto.

Alluvial gold has frequently been responsible for the spending of considerable sums in the endeavour to locate the primary rocky source. After extensive workings this, however, has hardly ever been found, though lodes or veins may have been disclosed which did not contain the high values and which were not the bonanzas of which the alluvial gold had been taken to be the indicator. One of the authors has had an opportunity of closely investigating five specific cases of this nature in Siberia. The deposits were situated in the southern part of the Urals, and a Russian mining foreman had set himself the task of finding the mother lodes of these deposits. Systematic and careful prospecting, however, discovered quartz veins containing only one or two dwt. of gold per ton. It was the opinion of the local men that such quartz veins could not have yielded either the rich placers or the large nuggets. Further investigations were carried out with negative results, and the operations were eventually stopped. One of the authors considered the disclosed veins to be the mother lodes of these deposits, although he could not then submit a satisfactory explanation of the occurrence.

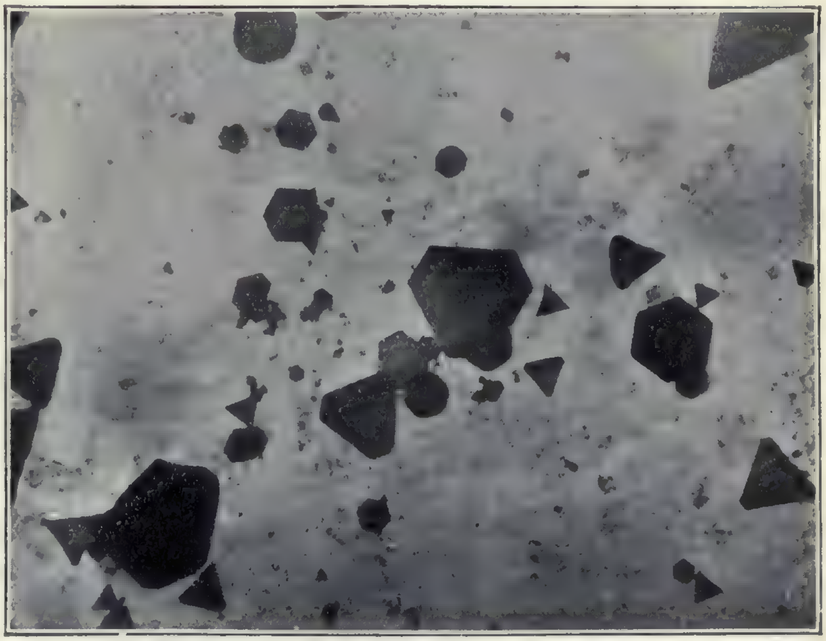
The existence of gold nuggets[9] or of rich outcrops has been ascribed to ascending waters containing gold from sources which need not be touched upon here, this being outside the scope of this paper. These waters when nearing the surface were gradually relieved of the pressure to which they were subjected at lower levels, some gas which was looked upon as the solvent became freed, and the gold was precipitated. The rich outcrops were accounted for in this manner. The formation of nuggets was ascribed to waters containing gold either passing over some crystal of pyrite, organic matter or other reducing agent. This assumption was based on exceedingly interesting experiments made by Professor Ulrich when at the University of Otago, also by Daintree, in 1871, when at Dr. Percy's laboratory at the Royal School of Mines in London.[10] The former obtained a small nugget of gold out of a chloride of gold solution, parts of the cork of the bottle acting as reducing agent; the latter obtained a cluster of gold crystals on the smooth surface of a crystal of pyrite. Similar experiments were made by Liversidge.

In either case the quantity of the gold deposited is a function of the quantity of the precipitating agent; when this is absorbed the precipitating action must cease, and a small amount of organic matter or a small crystal of pyrite cannot account for a large nugget.



SECTION OF GOLD ORE: COOLGARDIE (× 100 DIAM.).

When piercing the Simplon tunnel a vein of silicic acid in the gelatinous condition was discovered,[11] and it does not therefore seem too daring to assume a gelatinous state, as the transition between the original liquid and the ultimate solid form of a quartz vein. The solution which contained the silicic acid may also have contained the gold salt, and when this solution set to a gel this salt would be distributed uniformly throughout. It is, however, possible also that the silicic acid set to a gel first, after which the gold diffused into it. The reduction or precipitation of the metal was a subsequent process, and the reducing agent, as far as some alluvial deposits are concerned, most probably was a gas. Some recent researches by Arrhenius deal with the atmospheric conditions of the planets,[12] and it is pointed out by him that the earth's atmosphere before being what it now is, must have consisted of hydrogen, hydrocarbons and cyanogen. The latter compound in various combinations we know to be a solvent of gold, but the two former are reducing or precipitating agents in their behaviour towards the precious metal, thus furnishing the elements required for the fulfilment of the conditions underlying the above experiments.



GOLD CRYSTALS FROM SILICIC ACID (× 100 DIAM.).

Quartz with banded structure[13] finds a ready explanation identical with the formation of the strata mentioned in Experiment No. 6. If we again assume a vein of gelatinous silicic acid with uniform gold contents, and we assume surface waters containing the reducing agent to follow the quartz vein from the surface downwards through the salbands, we obtain ultimately a vein with bands of rich quartz lying parallel to the vein walls at the outcrop, gradually decreasing in richness as depth is attained, and simultaneously losing the banded appearance. An occurrence of this kind has been minutely described by T. A. Rickard,[14] who explains the bands in the quartz by means of a replacement theory which is not quite convincing, as it offers no explanation of the presence of bands of graphite found occurring with the gold. A reducing agent such as acetylene, petroleum, or other hydrocarbon with high carbon content, would account in a satisfactory manner for the deposit of carbon in proximity to the gold. Rickard also points out that the gold had completely given out in depth, and the mine was worked at the time of his visit for its quartz crystals only, which were found in the lower levels.

The probability of a quartz vein having been acted upon by reducing agents derived from the walls of the vein must, of course, not be lost sight of, and such a possibility will show the lateral secretion theory in a new light.

The authors are aware that the above experiments, which have been carried out with chloride of gold, yield pure gold only in the precipitated particles or crystals. Such gold is not known in nature, where a varying amount of silver is always present. With a view to obtaining crystallized gold of similar composition to that occurring in nature, another set of experiments is now progressing, on which it is hoped to report progress in due course.

[1] H. Pechhold, *Zeitschr. . physikal Chemie*, lii, 185 (1905).

[2] H. Bechhold & J. Ziegler, *Ann. d. Physik. IV*, vol. xx, 900 (1906).

[3] H. Hatschek, *Koll-Zeitschr. VIII*, 193 (1911).

[4] E. Hatscehk, *Koll-Zeitschr. IX*, ii (1912).

[5] N. Pringsheim, *Jahrb. f. wissensch. Botanik*, xxviii, 1-38, 1895.

[6] *e.g.* Rickard "The Indicator Vein, Ballarat," *Trans. of Amer. Inst. of Min. En.*, vol. xxx.

[7] *e.g.* McDermott. "The Silver Islet Vein," *Trans.* vol. xviii.

[8] This is a very complicated matter, owing to the difference between isotony and equivalence. If the gel contains, say three moles of gold chloride, and the aqueous solution two moles of sodium sulphite or ferrous sulphate, the latter can never become hypertonic, even if all the gold chloride has diffused out.

[9] Beck. "The Nature of Ore Deposits." p. 651.

[10] *Trans. of Amer. Inst. of Min. En.*, August, 1893.

[11] Spezia, *Atti, Accad. Torino*, xxxiv, p. 705 (1899).

[12] *Les Atmosphères des Planètes*, by Svante Arrhenius. Published by A. Hermann, 6 Rue de la Sorbonne, Paris.

[13] Dr. R. Beck. *The Nature of Ore Deposits.* 1905.

[14] T. A. Rickard, "La Gardette, the History of a French Gold Mine." *Amer. Inst. of Min. En.*, 1892.

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CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE PROGRESS OF BIO-CHEMISTRY.

Enzymes and Inhibitants.

By A. HARDEN, D.Sc., F.R.S.

IT has become apparent, as bio-chemical research has progressed, that one of the devices employed by the living cell to regulate enzyme action, is the simultaneous production of an inhibiting substance which either totally prevents the action of the enzyme or greatly modifies its intensity. Thus to take only a single example, in the yeast cell the powerful digestive enzyme—yeast endotryptase—is accompanied by an anti-protease, in the presence of which the action of the enzyme is largely diminished. (Buchner and Haehn.)

These two antagonistic agents pass into the juice expressed from ground yeast and can be separated by boiling the liquid. The anti-protease being thermostable is unaffected, whilst the tryptase loses its activity.

A still more interesting case, in which the enzyme and inhibitant occur actually combined together has been revealed by the researches of Dr. S. Hedin on Rennet, the results of which have recently appeared in a series of papers in Hoppe-Seyler's *Zeitschrift*.

Rennet is usually prepared by extracting the mucous membrane of the calf's stomach with dilute acid, and is then obtained in the form of a highly active solution. When, however, the extraction is made with cold water, the solution is found to possess only a slight degree of activity. If it be subsequently treated with dilute acid, however, it acquires a power of clotting milk equal to that of the extract made originally with acid. This phenomenon has been explained on the ground that the water extract contains an inactive mother-substance of the enzyme, or zymogen, which is converted by the action of the acid into the active enzyme. Hedin's experiments have, however, revealed the remarkable fact that this so-called zymogen is in reality a compound of the enzyme and an inhibitant, and that by suitable treatment either the active enzyme or the inhibiting substance can be obtained from it.

By treatment with dilute acid the active enzyme is liberated and the inhibitant destroyed, whilst with dilute alkali (ammonia) the enzyme is rendered inactive and the inhibiting substance left free. When solutions containing the two antagonistic substances are mixed, combination again occurs, and when suitable proportions are used the resulting liquid has only a very slight clotting power.

This is an observation of first-rate importance and is calculated to modify profoundly the whole body of opinion as to the nature of zymogens and of the process of enzyme production in the cell.

A comparative study of the rennet enzymes of different animals has brought to light a still greater complication. Inhibiting substances can be also obtained from the extract prepared by water alone from the stomach membrane of the pig, the guinea pig, and the pike precisely in the same way as from the calf. Each of these inhibitants when added in suitable amount to the rennet prepared from the same animal completely removes its power of clotting milk. When, however, the inhibitant from one animal is added to the active rennet from another animal, the inhibitant from the guinea pig for example to calf's rennet, or the inhibitant from the calf to guinea-pig's rennet, no inhibition whatever occurs—the relation of inhibitant to rennet is strictly specific. It follows from this that both the enzyme and its inhibitant are different for each animal, a fact of great interest and importance. In spite of this difference, however, all these enzymes are equally capable of clotting cow's milk. It appears, therefore, that identity of action upon a given substance is not sufficient ground for the conclusion that two enzymes are identical. In most cases, however, this evidence is all that is available. The invertase from each of the different yeasts, bacteria, moulds, etc., which contain it, is usually regarded as but one enzyme because it exerts the characteristic effect on cane sugar. In the light of Hedin's experiments this can no longer be assumed, the probability would indeed rather appear to lie in the direction that each of these is a distinct substance. Unfortunately no simple method of solving this fundamental problem presents itself at the moment, and the answer to the question must await further discoveries.

OILS, FATS AND MILK PRODUCTS.

By CECIL REVIS and E. RICHARDS BOLTON.

A VERY full investigation of Turkey Red oil has been published by Richardson and Walton (*Jour. Chem. Soc., Ind.*, 1912, xxxi., 35), which, besides containing the analytical details of the various constituents of the oil, also gives the ideas of the authors as to the probable constitution of the fat. As the full methods of examination are given, the whole investigation is distinctly interesting, particularly the scheme put forward by the authors with regard to the action of strong sulphuric acid on castor oil in the preparation of Turkey Red oil.

The Bulletin of the Imperial Institute, 1911, Vol. ix., No. 3, contains an interesting article on Bassia Fats. The analyses of the fats obtained from *Bassia latifolia, longifolia and butyracea,* are given and discussed, and attention is drawn to the fact that the fats of the two former varieties are very similar, while the latter differs somewhat both in texture and colour.

Their suggestion that the seeds of *Bassia butyracea* should be marketed under some other name than Mowra or Illipé kernels is undoubtedly good, and it is greatly to be desired that such a distinction might be carried further, as these names, particularly that of "Illipé," are used for such a wide variety of totally different products that they have practically ceased to have any designative value. The chemical constitution of these fats is also dealt with by Pelly (*Jour. Soc. Chem., Ind.*, 1912, xxxi., 98), particularly with regard to the glycerides present, and the results of this investigator seem to show that the three fats are considerably different in composition.

Among analytical methods a useful investigation has been made by Liverseege and Elsdon (*Jour. Soc. Chem. Ind.*, 1912, xxxi., 207) on Walker's modification of the Livache test for measuring the drying power of linseed oil, and they have modified the method still further as a result of a number of experiments, which modification appears to give concordant results when carried out in duplicate, and the method seems worthy of some attention as concordance of results was not a characteristic of the original method. They also point out that a very simple test for the genuine character of the oil, whether boiled or otherwise, consists in the simple addition of water to the oil after saponification in the usual way, and claim that 5% of unsaponifiable matter can be readily detected in this manner without any more elaborate examination. Of recently published figures for oils and fats, the following will perhaps be of interest :—

(1) Linseed oil by Sheppard (*Jour. Ind. Eng. Chem.*, 1912, iv., 14), though the figures deal with the yield of oil rather than with analytical results.

(2) Palm oil by Hebert (*Bul. Soc. Chem.*, 1911, ix., 1,083), analyses being given of the oil from several different varieties of the *Elaeis guineensis*. The figures show considerable divergencies, especially in the saponification value. We have previously drawn attention to the presence of hydrocyanic acid in many oil bearing seeds, in which connection the experiments of Ravanna and Vetthi (abs. *Jour. Soc. Chem. Ind.*, 1912, xxxi., 201) on the formation of hydrocyanic acid during the germination of seeds, particularly those of flax and millet, are distinctly interesting.

Their experiments show that the acid arises in the seed from an interaction between carbohydrates and ammonia, and it must be supposed that this production of hydrocyanic acid leads later to the reformation of a cyanogenetic glucoside which, in turn, appears in the fresh seed.

From an industrial point of view, a useful article appears in the Bulletin of the Imperial Institute (supra) on the cultivation of sesamum seeds for oil production, and there is no doubt that the larger production of this oil would be useful from many points of view, as the oil can be used for a variety of purposes, and the cake forms an excellent cattle feed. In this connection, the feeding experiments carried out with the cake at the Agricultural College at Wye are noteworthy, in that the butter obtained from the milk of cattle so fed does not give the well-known Baudouin reaction, in sharp contradistinction to the use of cotton seed cake which rapidly betrays its presence in the butter to the Halphen test.

There is not the least doubt that the production of sunflower oil is steadily increasing, and the production of this oil is one which might well engage the attention of the English farmer, as the steady and increasing utilization of all sorts of vegetable oils for margarine purposes should make the production a profitable one.

While speaking of this multiplicity of oils used for edible purposes, we must remark on a recent editorial in the *Lancet*, in which a note of warning was sounded on the indiscriminate use of vegetable oils. With regard to the oils there mentioned, we feel that the warning is unnecessary, as the greater number of them have been known and used from time immemorial.

Another contribution to the still obscure problem of the ripening of cheese has been made by Gorini (*Cent. f. Bakt. Abt.*, ii., xxxii., 1912, 406), who has isolated some varieties of acid proteolytic cocci which appear to be able to grow at 10°C., and to excrete enzymes which are active at as low a temperature as 5°C., and he is of the opinion that these organisms play a considerable part in the ripening of such cheeses as Parmesan, a view which certainly is in accord with that of the American school which believes in the use of ice cellars for ripening purposes. Löhnis (*Cent. f. Bakt. Abt.*, ii., xxxii., 1912, 202) in an address to the Fifth International Dairy Congress at Stockholm, reviews the whole subject of cheese ripening again in an extremely lucid manner, but as it is impossible to give his remarks concisely, the original paper should be consulted. In the same journal (xxxiii., 1912, 1) appear the results of a systematic and thorough investigation into the analytical and bacteriological nature of "Taette," the "thick" milk of Norway and Sweden, a product very little heard of outside its native home, but there forming a widely used and staple diet. It differs very much from the now very familiar "Yoghurt" and other "sour" milks, and also from "Koumis," etc. Though itself alcoholic and sour, its keeping qualities are much greater than any of these, and it has not the effervescent character of the last-named.

A method of producing condensed milk, which is likely to become of considerable importance in the near future, is the application of the Kestner evaporator for this purpose. The preparation of condensed milk by this method has passed beyond the experimental stage, and an evaporator which will begin to discharge condensed milk within 15 minutes of introducing the milk and then works continuously should be of interest to all those connected with this industry. The occurrence of reddish-brown patches in condensed milk is not uncommon, and the idea has been put forward that this is due to the use of a solution of resin in alcohol for soldering the tins. The heat produces traces of aldehyde and furfural which, reacting with the casein of the milk, produce the colour. When moulds, etc., cannot be demonstrated, such an explanation may be correct.

RECENT INVESTIGATIONS ON THE COMPOSITION OF CONIFEROUS WOODS.

By J. F. Briggs, A.C.G.I.

The study of the extremely complex question of the nature and constitution of the woody substance of the coniferous woods has been considerably advanced in the last two or three years by the researches of Professor Klason, of Stockholm. In 1911 he published a brochure, setting forth the results obtained from his investigation of the by-products of the manufacture of sulphite wood pulp. According to Klason, dry spruce wood contains about 10 per cent. of wood gum, yielding on hydrolysis 25 per cent. of pentose, and about 28 per cent. of lignin, which, however, is not in chemical combination with the cellulose and other carbohydrates. Lignin is a colloid having apparently a very high molecular weight; it is a mixture of at least two main constituents differing in their proportions of methoxyl groups. These constituents have been formulated by Klason as $C_{40}H_{42}O_{11}$ and $C_{39}H_{40}O_{12}$.

In connection with the sulphite process, Klason has put forward the hypothesis that lignin may be regarded as a condensation product of coniferyl and hydroxy-coniferyl alcohols, in which four molecules are condensed together with the elimination of $3H_2O$. This hypothesis certainly gives a simple and apparently a sufficiently complete working picture of the reactions which take place in the sulphite process of digestion of wood, but it has not been sufficiently developed in its general relations to other reactions to be accepted as a final solution of the constitution of the lignin molecule.

Attacking the problem in another direction, likewise in connection with the great Swedish national industry, he has also studied the by-products of the manufacture of wood cellulose by the sulphate process. In this process the wood is digested with a lye containing as active ingredients sodium hydroxide and sodium sulphide, together with sodium sulphate as a restraining agent. The subject was approached by Klason, first from the point of view of the recovery of volatile by-products: oil of turpentine and methyl alcohol. The methyl alcohol is derived from the methoxyl groups of the lignin, and part of it combines by a secondary reaction with the sulphur in the lye, producing methyl mercaptan and methyl disulphide, which are the cause of the abominable odour connected with this branch of the industry.

In a paper recently published by Klason and Segerfelt (German translation in *Der Papierfabrikant*, 1911, 9, 1093), the conditions which favour the production of mercaptan have been studied. It would appear generally that the higher the proportion of total alkali employed for the digestion the smaller is the proportion of mercaptan produced. This is explained by the fact that the mercaptan is a body with acid function which is partially converted by the excess of alkali into dimethyl sulphide, the odour of which is far less powerful. The quantities of methyl mercaptan and dimethyl sulphide therefore tend to vary inversely. Further, it is desirable that the proportion of alkali present in the form of sulphide should not exceed 20-25 per cent. of the total alkali.

The authors next turned their attention to the non-volatile by-products derived from the wood. By evaporating the black lyes to a syrup *in vacuo*, saturating them with carbon dioxide and then heating at 110°—120°C., the lignin was separated as a gritty, fused precipitate in the form of its sodium compound, having the composition $C = 59{\cdot}38$ per cent., $H = 4{\cdot}77$ per cent., and $Na = 6{\cdot}72$ per cent. Experiments had shown that about 0·7 per cent. of methyl alcohol on the dry weight of the wood is produced during digestion by the hydrolysis of the methoxyl groups of the lignin. On the assumption that wood contains 28 per cent. of lignin and 3·8 per cent. of methoxyl, it is calculated that the lignin itself contains 13·6 per cent. of methoxyl, equivalent to 3 methoxyl groups in the molecule of lignin; thus 0·7 per cent. of methyl alcohol represents half a molecule of methoxyl split off during the digestion. Assuming further that 2OH groups have become 2ONa, the lignin molecule $C_{39}H_{40}O_{12}$ should have become converted into $C_{38\cdot5}H_{37}O_{12}Na_2$, the calculated percentage of sodium in which would be 6·2, as against 6·72 per cent. found as above.

A further quantity of lignin was precipitated in the free state by treating the liquors with sulphuric acid after separation of the first precipitate. This first precipitate was also treated with acid to liberate the lignin and was purified by extraction with chloroform, whereby fatty and resinous acids were removed. The purified free lignin had the composition $C = 63{\cdot}31$ and $H = 5{\cdot}24$ per cent. and yielded 12 per cent. of methoxyl. From the filtrate there were obtained on distillation the volatile acids, formic and acetic, in fairly equal proportions. The residue after distillation contained lactones and lactonic acids, which were separated from the salts by treatment with alcohol and ether. The results obtained by the titration of these bodies corresponded well with the assumption that they are composed almost exclusively of saccharins and saccharinic acids with 6 carbon atoms.

Calculated on 1,000 grms. of dry organic matter in the waste lyes, the results are summed up as follows:—

Lignin	542·9	grms.
Fatty and resin acids	24·7	,,
Formic acid	36·9	,,
Acetic acid	51·6	,,
Lactones and lactonic acids	303·4	,,
Total	959·5	grms. accounted for.

Roughly speaking, these bodies may be taken as representing about 50 per cent. of the dry substance of the wood, since relatively high yields of cellulose were obtained.

According to Klason, the formic and acetic acids are probably derived from the pentosans of the wood gum, whilst the lactones and lactonic acids would be produced by the action of the alkali upon the readily hydrolysed hexose carbohydrates.

Working independently of Klason, Rinman (*Papierfabrikant*, 1912, *10*, 39 and 101) has arrived at somewhat similar results, if account be taken of the different conditions of investigation. Rinman digested the wood with a mixture of sodium hydroxide and sodium chloride, obtaining an average yield of only 37 per cent. of cellulose; the waste liquors would therefore contain a higher proportion of products derived from the decomposition of the cellulose than in Klason's experiments. The fraction described by Klason as "lignin" is termed "humus" by Rinman, who distinguishes those bodies precipitated by carbon dioxide by the name of "humus matters," whilst those precipitated by mineral acids are termed "humus acids." The sum of these two fractions always remains fairly constant, and they are apparently both derived from the same constituent of the wood, but their relative proportions vary with the conditions of digestion. Rinman states that the humus matter is not precipitated in the form of its sodium compound by treatment with carbon dioxide.

A further fraction, termed "soluble humus acids," may be precipitated as lead salts and liberated by sulphuretted hydrogen. One of the most interesting fractions of the liquors is that containing the lactonic acids; these acids are combined in the lyes with 40 per cent. of Na_2O, and certainly contain a considerable proportion of ordinary lactic acid which has been isolated and characterised.

The major portion of Rinman's work is devoted to the industrial side of the question, and he has developed a new process of digestion, substituting sodium chloride for sodium sulphide and thus eliminating the mercaptan nuisance. A new method of regenerating the soda by a wet process analogous to the ammonia-soda process has been investigated, also a process for obtaining the acetic and formic acids. The most successful outcome of Rinman's work is the recovery of valuable by-products, spirits, ketones, oils and charcoal by the destructive distillation of the organic matters separated from the lyes.

The Formation of Colloidal Metallic Sulphides in Rubber Solutions.— Messrs. Lewis and Waumsley have recently observed that when a strip of lead is immersed in a solution of rubber in benzole containing even traces of carbon disulphide, lead passes slowly into the solution, the latter acquiring a deep brown colour. In the entire absence of rubber no such change occurs, and with very low rubber concentrations (*e.g.*, 0·5 per cent.) the change is extremely slow. In 1 per cent. solutions of rubber, however, a distinct colouration is evident in the course of a few days. The change is hastened by the addition of traces of alcohol, and the speed is greater with high concentrations of carbon disulphide. But the rubber concentration appears to be the most important factor. The sulphide solution can be transformed into one of chloride, and reconverted into sulphide. The sulphide is converted into iodide by the addition to the solution of a benzole solution of iodine. Copper behaves in a similar manner, and mercury in a much less degree. A similar result is also obtained in the case of lead when an acetone solution of celluloid containing carbon disulphide is employed. (*Communicated to the Society of Chemical Industry.*)

UNIVERSITIES AND COLLEGES.

CITY OF BRADFORD TECHNICAL COLLEGE.—DEPARTMENT OF CHEMISTRY.

By PROFESSOR WALTER M. GARDNER, *M.Sc.*

THE Bradford Technical College was one of the earliest of the larger technical institutions established in this country, the present buildings dating back to 1882. The institution was begun on very sound lines, the policy adopted being that of concentrating effort on the chief industries of the district. As a result, three technical departments only were instituted, dealing respectively with the textile industries, the chemical industries, and engineering; and these, though greatly extended in scope, have not been increased in number.

GENERAL CHEMICAL LABORATORY.

The chief chemical industry of the district is the dyeing of textile fabrics, of which there is a great concentration in Bradford, and therefore the dyeing section has always been a very prominent feature of the chemical department. Since the introduction of the synthetic dyestuffs, the dyeing industry has been entirely revolutionised; in fact, for the last fifty or sixty years it has been in a state of continual change and development, owing to the production of new products and methods. The tendency throughout has been to render more and more important the chemical and physical aspects of the works' processes, until at the present time dyeing operations are rapidly becoming more or less exact chemical operations and empiricism of less importance. The result is that in the training of the future managers and heads of departments the scientific work has to be carried to a high pitch. Of the 50 to 60 day students in attendance each session in the department, about two-thirds take out a full diploma course, which as regards their chemical work involves an ultimate standard about up to that required for an honours degree. The course extends over a period of four years. In the later stages of their practical work, students are required to examine and report upon trade samples of soaps, oils, dye-wares, general chemicals, water, etc., using technical methods of analysis. The investigation of difficulties and defects actually occurring in the works, also affords much useful training. In addition to the diploma offered for the course in chemistry and dyeing, provision is made for a diploma in pure chemistry, a smaller number of students taking up this course which, as regards a great deal of the work, runs parallel with the applied course. As in

TECHNICAL LABORATORY.

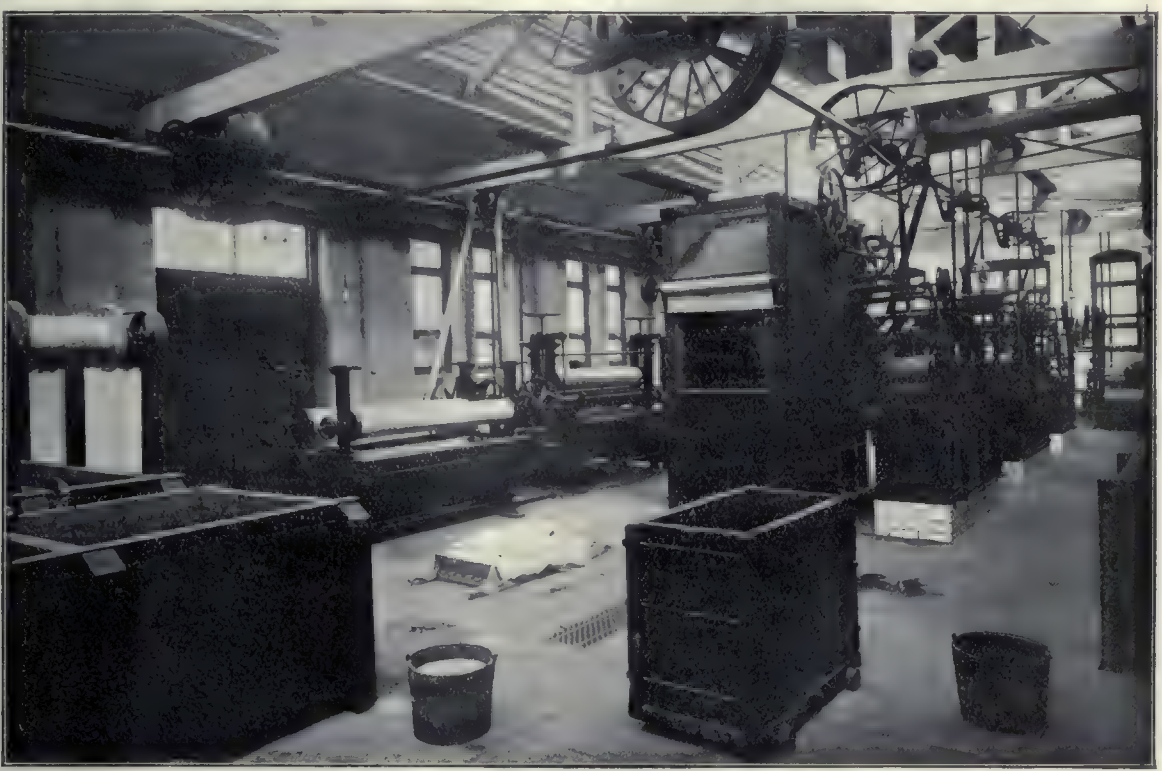
all large laboratories, there are also a few occasional students working up for the external degree of London University, the first professional examination of the Conjoint Board of Medical Studies, etc.

DYEING LABORATORY.

The staff on the chemical side is very strong, including in addition to the Professor, three Lecturers and two Assistant-lecturers and Demonstrators. Five members of the staff are University graduates and one is an A.R.C.Sc.

Realising the essential character of research work in the training of students, and the duty of the larger technical institutions to take their part in the accumulation of knowledge, a Lecturer was appointed a few years ago to devote his whole time to work of this character, a development which has undoubtedly been of the greatest value. This appointment of a research chemist was possibly the first to be made by a municipally managed institution in this country. In addition to the staff above enumerated, there is a Lecturer and an Assistant-Lecturer in dyeing, who are assisted by practical men in charge of the dyehouse and finishing rooms.

The college buildings being old, the chemical department is not so conveniently housed as would be practicable in a new building; the rooms, though adequate, being somewhat widely separated. There is a large Chemical Laboratory, with accommodation for 80 students, in which the general work is carried on. When sufficiently proficient, students are promoted into the Technical Laboratory, this normally taking place during the latter half of the third year. Here there is an electrochemical installation in addition to special appliances for technical work. A small Research Laboratory for six workers, a Furnace Room, and a room for Gas Analysis, complete the laboratory accommodation on the chemical side. The Chemical Library adjoins the Balance Room. The Dyeing Laboratory is a large room fitted with experimental dye-vessels of various types, and here the experimental work of investigating the mode of application, properties, identification, etc., of dyes, is conducted. A small lecture room is fitted up as a Colour Matching Room and equipped with lamps of various types to illustrate the optical properties of dyestuffs and their effect on the matching of colours. The Practical Dyehouse and Finishing Rooms have only just been equipped, and form a portion of what is virtually a small mill, in which textile material can be received in raw condition and carried through all the various stages involved in the production of finished textile material. The machinery throughout this extension, while capable of dealing with trade material and producing an article of commerce, has been specially designed for carrying out large scale experiments. The underlying idea is not to teach trade manipulation, but to provide facilities for the investigation and demonstration of the inter-dependence of processes and many other problems which can only be attacked on a large scale, but which, largely owing to commercial necessities, cannot be carried out in the works. The equipment of the Practical Dyehouse is such that loose wool or cotton, hanks of slubbing or yarn, yarn in the form of warps, or piece goods, can be dealt with, and in the Finishing Room the subsequent operations of stretching, singeing, raising, cropping, pressing, etc., can be conducted. The value of such college workshops has often been doubted, but this is due to a false idea as to their use and possibilities. In the training of the junior student they may serve mainly as improved lantern slides or diagrams, but to the graduate with trade knowledge they offer the best possible means of improving existing operations, developing new processes or effects, etc., and thus assisting the industries upon the development of which the large technical institutions are exerting such an important influence.



DYEHOUSE.

CLOTH FINISHING ROOM.

SURFACE COMBUSTION, AND ITS PRACTICAL DEVELOPMENTS IN 1912.

By John B. C. Kershaw, F.I.C.

A platinum crucible or a platinum wire, if raised to a red heat, and held in the stream of coal gas and air issuing from the top of an unlighted Méker gas burner, will be kept in a state of incandescence without the production of any flame, by flameless or surface combustion. This is the simplest experimental proof of the remarkable property of combustible gases discovered by Sir Humphry Davy, nearly 100 years ago—for when that great English chemist was carrying out his classical researches upon "Flame," in the year 1816, he found that in some cases and under certain conditions, a slow combustion set in at temperatures below the actual ignition point of the gases, with which his experiments were being made. Sir Humphry Davy was thus led to ask himself the question, "Can a metallic wire be maintained in a state of incandescence, by a slow combination or combustion of the two gases, without the production of any flame?" and a direct experiment proved that the answer was in the affirmative. Davy's further investigations proved that hydrogen was more susceptible to surface combustion than either carbon monoxide or ethylene; and also that several metals possessed the property of inducing surface combustion in a very high degree; those of the platinum group, when presented to the combustible gas mixture in a finely divided state, being pre-eminent in this respect. The well known method of igniting coal-gas and air, by allowing the gas mixture to impinge upon a mass of spongy platinum, and the use of palladium asbestos in gas-analysis, are examples of laboratory application of this property of finely-divided metals.

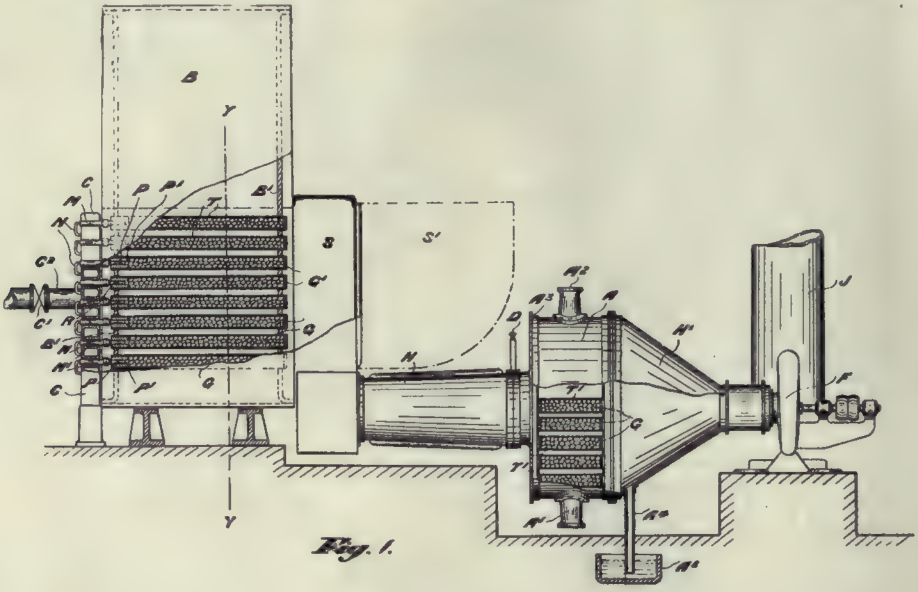


Fig. 1.

Davy's discovery of surface combustion excited much interest, and Dulong and Thènard, Dobereiner, Fusinieri, Henry, Graham, Faraday and de la Rive, all investigated the subject, and the two last named even engaged in a controversy relating to the theory of the process. But no practical developments followed, and as Professor Bone has pointed out, for a period of nearly sixty years the subject entirely disappeared from scientific literature. The revival of interest in surface of flameless combustion which has occurred recently is due to the practical developments that have followed from the work of Professor Bone, F.R.S., of Leeds University, and Mr. C. D. McCourt. These two investigators have worked out during the past two years the details of the application of this remarkable property of combustible gases to the practical needs of industrial operations, and a full sized steam boiler, with an evaporative capacity of 5,500 lbs. of water per hour, using their patented apparatus, has now been in operation at the Skinningrove Iron Works, Cleveland, Yorkshire, since November, 1911, with most successful results. The application of flameless combustion to the melting of metals, and to the evaporation and concentration of solutions of chemicals, have also received their attention, and it is quite confidently expected that now this method of burning combustible gases without smoke or flame, has been proved to be applicable to manufacturing operations, most important developments of the method will follow. The general character of, and special advantages claimed for, the new method of heating, have been thus described by Professor Bone in two lectures delivered in 1911 at the Royal Institution in London, and also at the Chemists' Club in New York.

"The distinguishing and essential feature of the new processes is that a homogeneous explosive mixture of gas and air, in the proper proportions for complete combustion (or with air in slight excess thereof), is caused to burn without flame in contact with a granular incandescent solid, whereby a large proportion of the potential thermal energy of the gas is immediately converted into radiant form. The advantages claimed for the new system are:—(1) The combustion is greatly accelerated by the incandescent surface, and if so desired, may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperatures is possible without the aid of elaborate "regenerative" devices; and (4) owing to the large amount of radiant heat energy developed, transmission of heat from the seat of combustion to the object to be heated, is very rapid."

"These advantages are so uniquely combined in the new system, that the resultant heating effect is, for many important purposes, not only preeminently economical, but also easy of control."

The high temperatures that can be attained, have been, in fact, one obstacle to the development of this system of heating for industrial purposes, Professor Bone and Mr. McCourt have found that when using rich coal gas the upper practicable temperature limit is determined by the melting point of the material used for the crucible or chamber being heated, and that even platinum can be melted and carborundum be decomposed into its elements by the new method of using gas for heating purposes.

For the very high temperatures obtainable with coal gas, water gas or natural gas, the inventors employ a bed composed either of fragments of magnesia, which has been burned at a high temperature, or of a neutral and highly refractory material specially prepared. In cases where the temperature required does not exceed 1,200°C., the bed of refractory material may be composed of a good quality of fire brick, crushed and meshed to a suitable size.

Gases of lower calorific values than coal gas, yield, of course, lower temperatures, but any combustible gas can be burned by the new system, to yield *its maximum temperature and heat efficiency*. A new field of use is thus opened up to coke-oven and blast furnace waste-gases, which have up to the present been too often allowed to escape into the atmosphere, on account of their low calorific value, and of the difficulty of obtaining, even a 50% efficiency from them, when they have been used for steam-raising or other heating purposes. The new system should prove of great use also when ordinary producer-gas is available for general heating purposes. As many engineers (including the writer) are convinced that the future of power generation lies with the internal combustion engine, the surface combustion system of heating will fit in perfectly with the present-day tendencies and future progress in the realm of power production.

The following details of its application to (1) steam-raising, (2) lead melting, (3) concentrating solutions, will serve to indicate the lines upon which present developments are occurring.

I. *Surface Combustion applied to Steam-boilers.*

The principle of this application is to fill the tubes of an ordinary multitubular boiler with the refractory material, suitably graded in size, and to draw in the gas mixture under sufficient pressure, to avoid the danger of back-firing. Owing to the rapidity with which combustion occurs, and the accelerated rate of heat transmission to the water, the size of the boiler required for a stated evaporative duty can be greatly reduced. The general principles of the design of the original experimental boiler erected and worked by the Radiant Heating Company at Armley, near Leeds, is shown, in sectional elevation, in Fig. I. Further particulars need not be alluded to in greater detail on the present occasion.

This experimental boiler was of the multitubular type, and possessed ten steel tubes, each 3 ft. in length by 3 in. in diameter. Each tube was packed for seven-eighths of its length with the refractory material suitably graded in size, while at the front end of each tube was placed a fire-clay plug, pierced with a hole $\frac{3}{4}$ in. in diameter. This plug served the double purpose of keeping the front end of the boiler cool, and of preventing "back-firing," as the speed at which the gaseous mixture was forced through the aperture was greater than the speed of the explosive wave. Attached to the front plate of the boiler was a mixing chamber of special design. An economiser, provided with nine tubes, each 12 ins. long and 3 ins. in diameter, and packed with the same material as the combustion-tubes, completed the heating system. The pressure under which the gas mixture was blown into the boiler was equal to 17·3 ins. (water gauge); the exit gases escaped into the economiser at a pressure of 2 in. (water gauge). The steep pressure gradient was due to the resistance offered by the fire-clay plugs, and also by the packing in the boiler and economiser tubes. The power expended in operating the blower was stated by the designers of the boiler to be only 4 per cent. of the total power generated.

Under working conditions, this small experimental boiler had consumed 1,000 cubic feet of coal-gas per hour, and had shown a *net* evaporative efficiency of 90·3 per cent. The combustion of the gas mixture was completed before the gas had traversed one-third of the length of the tubes, and the central portion of the core of refractory material was maintained in consequence at a very high temperature, which facilitated rapid transfer of the heat to the water in the boiler by radiation. Sixty-five per cent. of the work of the boiler was, in fact, done over the first foot length of the tubes, and the violent ebullition which occurred here promoted rapid circulation of the water in the boiler. The evaporative duty per square foot of heating surface per hour (from and at 212°F.) was 20 lbs., and could be forced up to 30 lbs., as compared with 7 lbs. to 8 lbs. for an ordinary Lancashire boiler, and 10 lbs. for a locomotive boiler. The following are figures obtained during a test run of the boiler:—

The amount of coal-gas supplied to the boiler, expressed as dry gas at 0 C. and 760 mm., was 996 cubic feet per hour. The net calorific value of the gas was 562 B. Th. U. per cubic foot.

The total heat supplied to the boiler, in terms of the net calorific value of the gas, was 559,800 B. Th. U. per hour.

The actual amount of water evaporated was 450·3 lbs. per hour. The actual heat transmitted to the water was $450{\cdot}3 \text{ lbs.} \times 1{,}172 = 527{,}800$ B. Th. U. per hour. The ratio between the heat transmitted to the water and the heat supplied to the boiler was, therefore, $\frac{527{,}800}{559{,}800}$, equal to an efficiency of 94·3%.

Deducting the steam used for operating the blower, this gives a net efficiency of 90·4 per cent., which is considerably higher than any yet obtained with coal or gas-fired boilers.

Further advantages of this system of steam-raising are:—The rapidity with which steam can be raised, and its elasticity. Starting with the ten-tube boiler all cold, steam at 120 lbs. pressure could be obtained in twenty minutes; and the gas mixture can be shut off certain rows of tubes as the demand for steam falls.

The success attained with the small experimental boiler at Armley led to the designs for a full-sized boiler being prepared. This boiler was constructed and erected at the shops of Messrs. Richardson, Westgarth & Co., Middlesborough, last year, and has been in operation at the Skinningrove Iron Works, Cleveland, Yorkshire, since November 7th, 1911, utilising the waste gases from a battery of Otto Hilgenstock by-product coke-ovens. The large boiler possesses 110 combustion tubes, and a steaming capacity of 5,500 lbs. of water per hour. Although the feed water is not specially treated to remove lime salts, no troubles from scaling have occurred. The Manager of the coke-oven plant reports, under the date of February 10th, 1912, that the boiler has continued to work satisfactorily, and that it is undoubtedly the cheapest steam-producer yet devised. The exit gases from the economiser show only a temperature of 78° to 80°C., which indicates that the installation possesses a higher thermal efficiency than the 94·3 % of the Armley Plant.

II. *Surface Combustion applied to Lead Melting and to other metallurgical purposes.*

The principle of this application is the same as that employed for steam-raising, the combustion tube (or tubes) containing the refractory porous material being fixed vertically in an iron tank, suitably lagged, to prevent loss of heat by convection or radiation. When once this tank has been heated up to a temperature of 400°C. it will work for days with little attention, the solid lead being fed into the tank from above, and the molten metal being withdrawn as required, by an overflow spout at the side. By means of this apparatus, lead, or any other fusible metal or alloy, may be melted very rapidly, and with a very low consumption of gas. Actual tests of a lead-melting tank of this type, containing only one combustion tube, showed a thermal efficiency of 68·6%, and it is considered that under better conditions of operation the method could be made to yield an efficiency of 80%. This method of heating can of course be applied to a great variety of other metallurgical uses. Figs. II. and III. show sectional elevations of a crucible and muffle, arranged for the application of this new principle of heating.

III. *Surface Combustion for evaporating and concentrating solutions.*

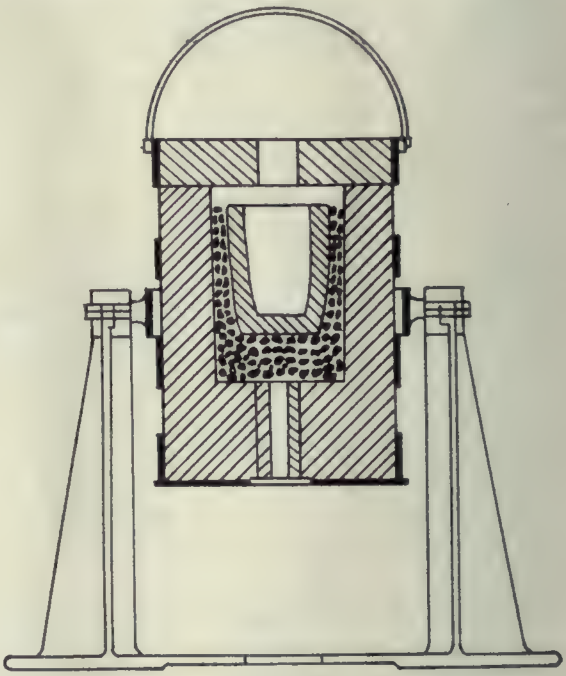


Fig II.

The surface combustion method of heating would appear to have a wide field of utility open to it, in the evaporation and concentration of solutions, in the chemical and allied industries. For this purpose the gas mixture is burnt at the surface of a porous diaphragm, made of granules of the refractory material. The diaphragm is mounted in a suitable frame, which can be held in a horizontal position above the surface of the liquid that is to be evaporated.

The porosity of the diaphragm must be graded to suit the particular kind of gas for which it is to be used, but for undiluted coal-gas, or coal-gas containing only a small proportion of water-gas, a diaphragm so porous that the gaseous mixture will readily flow through it, at a pressure of ½ in. water-gauge, should be employed.

The space between the casing and of the diaphragm constitutes a convenient feeding chamber for the gaseous mixture, which is introduced at the back. Such a mixture may be obtained in either of two ways:—(1) By means of suitable connections through a Y-piece, with separate supplies of low pressure gas and air (two to three inches, water-gauge, is sufficient); or (2) by means of an "injector" connected with a supply of gas at 2 lbs. per square inch pressure. The gas in this case draws in its own air from the atmosphere in sufficient quantity for complete combustion, the proportions of gas and air being easily regulated by a simple device.

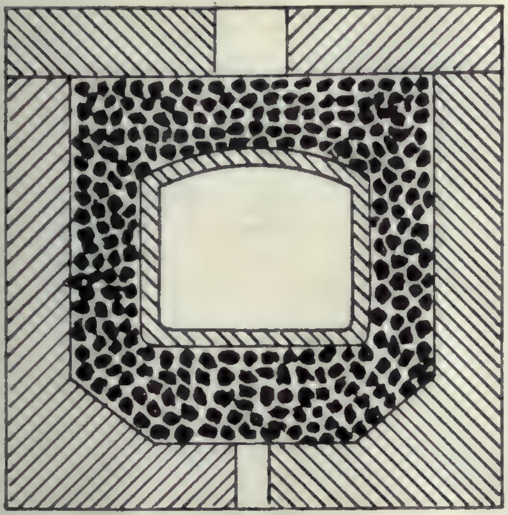


FIG. III.

"To start up a diaphragm, the gas is first turned on and ignited, as it issues at the surface; air is then gradually added until a fully ærated mixture is obtained. The flame soon becomes non-luminous and diminishes in size; a moment later, it retreats on to the surface of the diaphragm, which at once assumes a bluish appearance. Soon, however, the granules at the surface attain an incipient red heat, producing a curious mottled effect; and finally the whole of the surface layer of granules becomes red-hot, and an accelerated 'surface combustion' comes into play. All signs of flame disappear, and there remains an intensely glowing surface, a veritable 'wall of fire,' but without flame, throwing out a genial radiant heat, which can be steadily maintained for as long as required."

This method of heating and evaporating by means of radiant heat, applied at the surface of the liquid, is especially applicable to the evaporation of solutions of silicate of soda, or of sulphuric acid.

One of the latest applications of diaphragm heating is in the calico printing industry, for the purpose of burning-off the short threads and hairs, that cover the bleached goods, before they pass under the printing and finishing rollers.

The details given above of the practical applications of the surface combustion method of heating, have been drawn chiefly from Professor Bone's lectures on the subject, delivered in London, Philadelphia and New York. The writer's thanks are due to Professor Bone and to the Radiant Heating Syndicate, for assistance in preparing this article.

GLYCERINE: ITS PRESENT HIGH PRICE.

THE commercial history of this important article of commerce during recent years has been noteworthy, because what was formerly, in fact as well as in name, a mere worthless material to be got rid off, is now a valuable by-product, which no soap manufacturer would think of throwing away. Leaving out of consideration its use for pharmaceutical purposes, glycerine is now used for quite a large variety of industrial purposes, but its consumption for all trade uses is relatively quite small compared with the quantities required in the manufacture of nitro-glycerine, used as a basis for a variety of explosives now available for various purposes. Glycerine in its various forms is, therefore, a finished product as well as a raw material. As the main constituent of the most generally used high explosives, more especially dynamite, glycerine is a material of the utmost importance in several important industries.

Many of our great engineering works, such as docks, reservoirs, harbours and railways, would have been impossible if glycerine had still been a waste material. Moreover, to quote an expert, "apart from its importance as a constituent of modern blasting agents, which alone have rendered feasible so much of the remarkable engineering of recent times, glycerine has for this country a national importance as an indispensable element in the composition of cordite."

With the exception of a few soap-makers who confine themselves to soft soap and those who make up common soap into toilet tablets and other special forms, all others —that is, the most numerous and principal ones—produce glycerine, and most of them boil down their own liquor to crude glycerine; only few undertake the next stage of refining. The average soap manufacturer disposes of his crude glycerine either to another maker or refiner, or to a manufacturer of explosives who refines. His market, in the latter case, is a very limited one. Subject to generally yearly contracts, large quantities of crude glycerine are purchased by the Nobel Dynamite Trust Company, Ltd., and there is also a ready market for it in the United States. The great Nobel Trust, the largest purchasers of glycerine, has a capital of £4,000,000, of which £3,285,000 has been paid up, of which £2,285,000 are ordinary shares, which have for many years earned a dividend of 10%. Among the sellers are Messrs. Joseph Crosfield and Sons, Ltd., the great soap and chemical manufacturers of Warrington; the United Alkali Company of Cheshire; Messrs. Geo. Haller and Company, and others. The refining of glycerine is carried out by many of the larger soap manufacturers. At the National Cordite Explosives Works refining is not one of the processes gone through. The material is purchased ready for use from refiners. There have been great fluctuations in prices during recent years, through which the interests of the producers of the raw material and of the refiners have been in direct opposition. For a considerable period the latter have had the upper hand, and more recently the soap-makers, who produce the crude glycerine, have had the advantage. The present prices are: £60 per ton for crude 80% glycerine, and for industrial C. G. 1260, £87 per ton; the difference for refining being thus £27 per ton. Whether high prices are due to a trade or process being in few hands, or to natural laws of supply and demand, are moot points which cannot be discussed here. The recent fluctuations have been as follows:—Five years ago the price of crude glycerine was as low as £28 10s. per ton, £31 10s. below the present level, and the price for the industrial or refined material, £50; that is, £35 below the present level. The essential point is that then the margin between the crude and the refined was £21 10s. and now is £25. Last summer the price of crude was £42. The crude material furnished by the producers contains 20% of waste matter. The present price of £60 per ton in effect, therefore, represents a price of £72 per ton, that is one-fifth more; that reduces the margin from £25 given above to £13, to cover the present cost of refining.

The increase of price of crude glycerine may be accounted for by increases in the cost of the raw materials used, mainly oils and fats. Thus the present price of refined cotton seed oil is £25 to £27; five years ago the price was £24 per ton; more recently it has been £34 to £35 per ton. Tallows now cost £30 to £35 per ton, compared with £29 five years ago. Soap manufacturers who did not refine their glycerine were placed at a disadvantage, they had to pay more for their raw materials, whilst the prices of soap remained constant. On the other hand, the larger soap manufacturers, who were also refiners, could compensate themselves for the higher prices paid for the oils and fats they required by the steady demand for their refined glycerine and the splendid prices consumers were prepared to pay for it. An important point is that the raw materials now used for soap-making are also used by other trades which use the materials without extracting the glycerine. This applies essentially to cotton seed from which the oil is obtained. Formerly it was a waste product of the cotton-growing districts to be got rid of anyhow; now it is a most important article of commerce for which there appears to be an unlimited demand. It is required not only for the manufacture of soap, but as an important article of food in the form of margarine or butter substitute, in which state the glycerine is not abstracted. That necessarily limits the quantity of glycerine that can be produced, and may account for the high price now obtained for crude glycerine, £60 per ton, compared with £28 or £29 a few years ago. There must be a steady demand and a supply which is scarcely equal to it. Reference has been made above to the use of glycerine for explosives, both for engineering works and for army and navy purposes. In these directions the demand is also an increasing one. During recent years engineering works of the largest magnitude have been in progress. Practically no great undertaking can be carried through without the use of explosives. There is therefore a constant and assured demand, and for national purposes a large one in the future seems also certain. A material therefore which is absolutely required in large quantities for many purposes—for food, engineering and national—seems likely to maintain its high level of price, both in the crude and the refined form.

The export and import trade of glycerine in both forms is also considerable. The quantities and values of exports of the material produced in this country, have been as follows recently (the details for 1911 are not yet available):—

	1906.	1907.	1908.	1909.	1910.	
Cwt.	157,000	199,000	77,000	115,000	149,000	crude
			79,000	84,000	88,000	refined
	£307,000	£379,000	£138,000	£239,000	£388,000	crude
			£205,000	£236,000	£314,000	refined
Totals			£343,000	£475,000	£702,000	

It is only during recent years that separate figures have become available for crude and refined glycerine. It will be noticed that our exports are steadily increasing, they have more than doubled in five years, but the increase is mainly due to the export of the crude material. In 1906, the export price was £39 1s. 8d. per ton averaged for both crude and refined, in 1911 it had increased to £59 3s. 4d. per ton; an increase of no less than 70%. We export crude glycerine to Germany, the United States and Canada. Those to Germany are rapidly declining—they are now only a third of what they were during 1906—while those to the United States have increased more than four-fold. Our main exports of refined glycerine are sent to Portuguese East Africa, in very rapidly increasing quantities, to Japan and France, and in small quantities to Norway, Germany, and the United States. The quantities are as follows for crude glycerine:—

		1908.	1909.	1910.
To Germany	cwt.	16,000	3,000	3,000
		£27,000	£6,000	£9,000
To United States	cwt.	31,000	77,000	126,000
		£51,000	£143,000	£263,000
To Canada	cwt.	4,600	9,000	6,000
		£18,000	£23,000	£19,000

The refined glycerine is exported as follows:—

		1908.	1909.	1910.
To Portuguese East Africa	cwt.	1,900	15,200	22,800
		£5,200	£41,300	£61,300
To Japan	cwt.	4,400	4,900	8,000
		£11,400	£17,400	£32,300
To France	cwt.	3,709	2,600	2,300
		£10,400	£8,700	£10,400

Our imports are essentially crude glycerine from the Netherlands, Germany, Belgium, France, Italy, Russia, Sweden, Spain, and the Argentine Republic. Two-fifths come from France in increasing quantities as shown below:—

		1908.	1909.	1910.
From France	cwt.	25,000	19,300	24,400
		£49,300	£39,700	£61,700
From Belgium	cwt.	6,700	6,900	9,400
		£13,800	£16,700	£26,300
From Germany	cwt.	2,300	6,000	15,500
		£2,300	£6,000	£15,500

Distilled glycerine is imported mainly from Germany and the Netherlands, as follows:—

From Germany	cwt.	2,600	3,400	4,300
		£7,600	£11,800	£18,700
From Netherlands	cwt.	700	6,300	5,900
		£1,900	£17,900	£24,100

Our total imports of both crude and refined glycerine have been as shown below:—

		1908.	1909.	1910.
Crude	cwt.	51,800	51,900	67,200
		£95,500	£111,400	£179,900
Refined	cwt.	3,600	10,000	11,800
		£10,200	£30,600	£49,900

Portions of the above were exported, the balance being kept for use. Practically only the crude was exported, the quantity ranging from 11,800 cwt., worth £21,000, during 1908, to 18,500 cwt., worth £49,800, during 1910.

T. O.

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER IV.—(*Continued.*)

IN connection with this advance, the investigator will welcome the ever-growing list of text-books devoted to special subjects. In many cases, these afford a ready means for reference to the salient points in theory and practice connected with some special branches of modern investigation. This new factor widens out the horizon for the worker by increasing the facility with which general information may be obtained.

A few examples may be considered here, which suggest themselves, in passing, as having reference to this special development.

The first one chosen is that of bio-chemistry. Meldola has pointed out, (*Chemical Synthesis of Vital Products*, 1904) that even if we have in the field of carbon chemistry produced thousands of compounds which do not, and probably never will be found to, exist in living organisms, there is no justification in assuming that we have reached a stage where it is unimportant whether an organic compound is producible by vital chemistry, or that the known laboratory methods are equivalents of the unknown vital ones.

A simple case will illustrate this. "The fundamental synthesis *par excellence*, in which carbon dioxide is absorbed by an organised compound and the product, or products, decomposed with the liberation of oxygen, is as yet without a laboratory parallel." In a similar way it may be claimed that although such actions as those due to enzymes may be imitated by laboratory methods, yet no hydrolysing agent of the nature of an enzyme has ever been synthesised.

It is therefore essential, that the chemist and physiologist should work together. Their relative dependence is the watchword of modern investigation in this direction. Only in this way can the future of bio-chemistry be assured, and this science established on a firm basis. The subject is a fascinating one, and of great importance to the student in search of subject matter for further investigation.

In a similar way the proteins offer an ever widening field for research, as a reference to the Chemistry of the Proteins by Mann (1906) will readily indicate. Here the conditions are exceedingly complex, and an almost unexplored region is yet to be covered. Future developments in this direction cannot fail to be of a startling nature, and of equal importance to the physiologist as the chemist.

The subject of the alkaloids offers another field which may be expected to yield results of great practical and theoretical importance. A reference to vegetable alkaloids by Pictet and Biddle (1904), or to a series of volumes published in 1900, 1905, and 1908 respectively, under the title *Die Alkaloidchemie,* will give the investigator some indication of the scope of this branch of chemistry, and its present position.

In the same way, it is difficult to over-estimate the interest which catalysis, and the general reactions which are classified under this heading, offers to the investigator, especially when the recent developments in this direction are remembered. In its modern phrase it has been extended to organic chemistry. As practised at high temperatures by Sabatier and Sanderens and others, it can be practically utilised in many ways, as in processes involving reduction, hydration, oxidation, and elimination of halogen hydride, etc. On the industrial side, Ostwald has made practical use of this action in the manufacture of nitric acid. Its use in the manufacture of sulphuric acid is common knowledge. These interesting processes are being extended industrially. The possibilities have not been exhausted, in fact, developments of an increasingly important nature must continually be expected.

As the successful application of these methods generally turns upon attention to minute detail, systematic research is the only instrument which will advance our knowledge in this direction, especially as many of these changes are under certain conditions reversible ones. The theory is undeveloped, and the practical position may be regarded as almost virgin ground. The influence of third substances in minute quantity may alter the normal direction of the reaction, or may determine by their presence, or absence, the success of such processes from a commercial point of view.

In recent annual reports of the Chemical Society a general summary of results obtained in the domain of organic chemistry will be found.

"Unsaturation" offers a wide field for research. Also the relation between colour and constitution, which may throw light upon many other reactions, and help to explain the mechanism of chemical change, are matters of first importance.

Physical chemistry, in its different branches dealing with such subjects as the solution state, molecular weight, thermodynamics, chemical dynamics of homogeneous and heterogeneous systems, chemical equilibrium, and many other subjects has under modern enquiry developed to an amazing extent, but such investigation demands exact knowledge and the use of special apparatus before research can be undertaken with any advantage.

Stereo-chemistry, dealing as it does with space—as distinct from structural—formulæ has given rise to speculations of an advanced character. Some idea of its present scope may be gained by reference to *Stereo-chemistry,* by A. W. Stewart (1907) in the *Text Books of Physical Chemistry* Series, where the phenomena of steric hindrance, relation between space formulæ and chemical properties, substitution and stability, and other equally important questions are dealt with.

The present position of organic chemistry is complex to a degree. In *Die Synthetisch organische Chemie der Neuzeit* (1908) Schmidt deals with the advance in synthetic organic chemistry. If the student will refer to Cohn's *Algemeine Gesichtspunkte der organischen Chemie,* he will find many hints which will be invaluable in the conduct of research in this direction. Beilstein's *Handburch der organischen Chemie* and Richter's *Lexicon der Kohenstoffverbindungen* are indispensable reference books for all points of detail.

Fischer's work has been reprinted in a series of publications dealing with the sugars, purines, and polypeptides respectively, and a study of his work and methods is particularly interesting to the student.

Enough has perhaps been said as to the importance of research in connection with theory and the practical results which have followed investigation on such lines. Whether by this means we shall ever arrive at the ultimate goal, which has been defined by Freer (*Introduction to Laehmann's Spirit of Organic Chemistry*) as a "perfect human knowledge by which from any given premiss the logical conclusion may be drawn with unerring accuracy," is impossible to surmise from the data available.

The student may regard with a sense of awe the increase in the number of important sub-sections of chemical research within the last decade. He may trace the rise of stereo-chemistry to the recorded results connected with optical activity, and a determined and definite search for an optically active compound owing its asymmetry to the molecular alone, and not to an asymmetric carbon atom. As indicating the inter-relation between different branches of science, the relation of stereochemistry to physiology is a matter of first importance.

The whole question of the action of enzymes is also one which can hardly fail to offer the investigator a fruitful harvest to his labour. A study of recently published work will give an idea as to the aims and objects of this special work.

Recent developments are but the promise of a richer and more far-reaching harvest in the future. This certain fact cannot fail to create within the young investigator's mind a deep enthusiasm, when the vast extent of yet unexplored ground to be covered, and the results which may be expected are fully realised.

There is hardly a science, or an art, which can reasonably expect to escape the attention of the chemist, or the influence of chemistry. This is seen in the fact, that physical science is but a latter day development of this science; and recently Prof. Rutherford has claimed that in electrical engineering, the pioneers were the physical men. (*Eng. Sup. Times,* 20 Oct., 1910). New sciences spring up, and seemingly develop on original lines, only to be subsequently inter-related and closely woven into the general fabric, which, elected on a sure basis of research, is helping to determine the future physical destiny of man.

(*To be continued.*)

NOTES OF MEETINGS, &c.

THE CHEMICAL SOCIETY.

June 6th and 20th, at 8.30 p.m.—Ordinary Meetings.

* * *

SOCIETY OF PUBLIC ANALYSTS.

June 5th, at 8 p.m.—Ordinary Meeting.

* * *

SOCIETY OF CHEMICAL INDUSTRY.

June 3rd, at 8 p.m., the following Papers will be read:—"The Nature of the Process of Oxidation" (with demonstrations), by H. E. Armstrong, F.R.S., and R. T. Colgate; "Some Present Day Aspects of the Match Industry," by E. G. Clayton.

* * *

ROYAL INSTITUTION OF GREAT BRITAIN.

June 1st.—Willis L. Moore, "The Development of Meteorological Science."
,, 3rd.—General Meeting.
,, 7th.—Sir William Macewan, "Lord Lister."
,, 8th.—Willis L. Moore, "The Utilities of Meteorological Science."

OPTICAL CONVENTION, 1912.

June 19th to 26th.

THE Organizing Committee consists of about one hundred gentlemen, and comprises a large proportion of eminent men of science and leading manufacturers, under the general presidency of Professor Silvanus P. Thompson, D.Sc., F.R.S. The Hon. Treasurer is the Right Honourable Lord Justice Fletcher Moulton, P.C., F.R.S. The Executive Committee consists of twenty-four selected members of the Organizing Committee, under the chairmanship of Dr. R. Mullineux Walmsley, F.R.S.E., and it is assisted by a Committee on Papers, an Exhibition Committee, a Catalogue Committee, a Finance Committee, and Provincial Committees in course of formation in the principal towns and teaching centres of the United Kingdom.

The object of this Exhibition is to improve the local manufacture of optical instruments in this country.

In response to this request, the President of the Board of Education has very graciously promised to find housing space for the Exhibition in the buildings of the Science Museum.

Mr. J. W. Gordon is the Hon. Secretary, and W. T. Dunn is the Secretary to Executive Committee, 39, Victoria Street, Westminster, S.W.

CHEMICAL ENGINEERING.

THE "STEREOPHAGUS" PUMP.

By J. G. Davis, B.Sc. (Eng.), A.C.G.I.

The special advantages possessed by centrifugal pumps over liquid raising devices of other kinds have long been recognised, and so desirable has the employment of such pumps become in cases where the lift and discharge are considerable, and possibly variable, that much labour and ingenuity have been brought to bear upon their design. The resulting pumps, each designed for known conditions of working, have attained a standard of hydraulic efficiency of some 80% for pumps of very high lifts. Practice has indicated the seeming impossibility of passing much beyond this, owing to the unavoidable losses in converting the velocity of whirl into an equivalent pressure head. The various devices adopted to minimise this loss, consisting in modifications of the blades carried upon the rotating impeller of the surrounding casing or "scroll" into which the water is discharged from the vanes, and of the inlet and outlet passages of the pump, and in particular the exposal of the shaft or of any projecting edge to the direct flow, have, in certain cases, rendered the admittance of liquid containing solid or fibrous matter a source of permanent injury, or at least of temporary breakdown by blocking of the passages or by hampering the motion of the rotating parts.

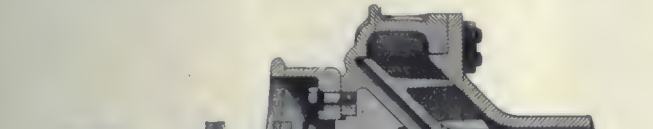


Fig. 1.

The difficulty of combining high efficiency with ability to pass any considerable amount of foreign matter, except in the form of silt or mud, has hitherto prevented the use of centrifugal pumps in innumerable cases. Their undeniable advantages of simplicity of action, compactness, low initial cost, and eminent adaptability to electric motor-drive under the most efficient conditions, have not for this reason been largely utilised. In cases where reciprocating pumps have been employed for small or for large discharges, the introduction of solid matter in the liquids pumped has led, respectively, to clogging of the valves or of the bars placed for constructional reasons between the several valves, both at inlet and outlet to the pump.

The use of "screens" for intercepting the solid substances and preventing their entry to the pump proves to be both inefficient and costly, owing to the often offensive nature of the screenings—in sewage work particularly—and the need for frequent cleansing of the screens to avoid flow being impeded.

There are two alternatives to either of the above systems of pumping, used most commonly in sewerage schemes, in which screening can be avoided. In the first of these some form of air compressor is used in combination with a pneumatic ejector, by means of which compressed air is automatically admitted to the ejector when full of the crude liquid, forcing the latter through iron pipes to the desired level.

In the second method a hydraulic pressure device is substituted for the air-compressor, the high pressure liquid being used to actuate the ram of a specially constructed hydraulic pump, so forcing the crude liquid, which is periodically entrapped in a suitable chamber on that side of the ram remote from the pressure supply, through a flap valve devoid of all bars or projections. There are serious objections to both these methods, and to certain more modern methods to which they have given rise, as the size and cost of the apparatus employed is increased solely because it must be sufficiently large to pass the liquid in an unscreened state, irrespective of the volume, and also in the necessity for the construction of special machinery for compressing the fluids, and the high cost of maintenance of such plant.

It has long been evident, therefore, that the introduction of a centrifugal pump, the action of which would be unaffected by the entrance into it of solids of any considerable bulk, particularly those of a fibrous nature, would vastly increase the sphere of action of this superior method of pumping liquids. The "Stereophagus" pump fulfils these conditions. In construction it differs from the ordinary centrifugal pump in that the liquid is admitted to one side only of the impeller, the latter being conical instead of cylindrical in form as usually. The impeller blades are set on one side only into the shrouding of the impeller, from which they project so that their edges terminate on an imaginary surface of conical shape, as indicated in Figs. I. and II.

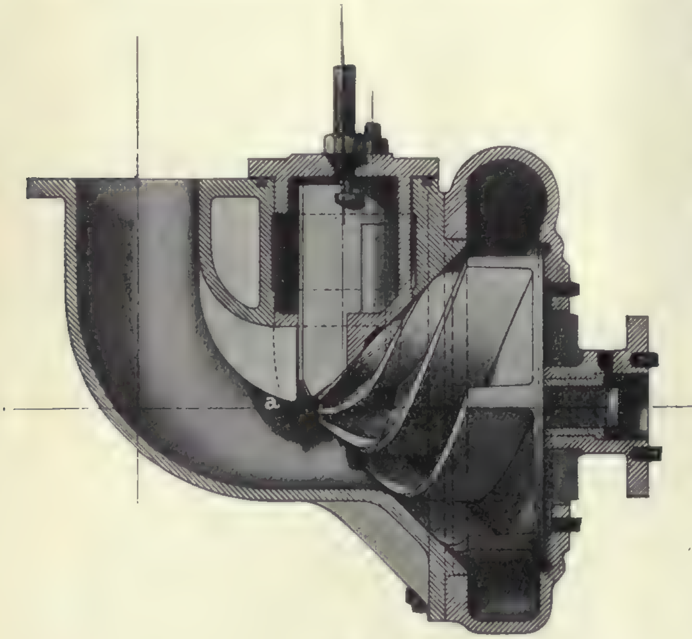


FIG. II.

The spiral chamber or scroll leading to the outlet of the pump surrounds the impeller periphery as in an ordinary centrifugal pump, although in the more recent designs (not illustrated here) a pear-shaped section has been adopted with increased efficiency. The edges of the blades fit closely against the internal face of the casing, which is formed with the same angle as that of the imaginary enveloping cone above mentioned. Cast at the side of this casing is a watertight cylindrical chamber, in which a steel knife or cutting-blade is set at an adjustable depth by means of a suitable blade-holder. This knife is arranged to have a sloping cutting edge lying along the surface of the impeller blade cone, and converging towards its apex (near a, Fig. II.), as shown in the view representing the outside of the impeller. The up-stream side of the knife is directly behind and in line with a protecting fin or director-web (a, Fig. II.) attached to the interior of the inlet pipe, which projects to the centre of the latter, and has its up-stream edge gradually merging into the inlet casting. The point of the knife reaches practically to the centre of the impeller. The action of the pump when charged and set in motion consists in drawing liquid through the suction pipe, passing it between the blades of the revolving impeller and thence ejecting it through the delivery pipe *viâ* the scroll or spiral casing. Any solid or fibrous matters present are guided by the fin towards the apex of the impeller, and, coming into contact with the revolving blades, are carried to the edge of the knife and sheared into pieces. At the point where cutting so occurs the passages between the blades of the impeller are of smaller dimensions than at any other point in the pump, so that, once cut sufficiently small to pass the knife, every piece of solid substance can pass easily through the remainder of the passages to the outlet. Should the first cut leave the piece still too large, it will be re-cut each time it reaches the knife until it goes through freely. The slicing up of a substance in this way by a progressive shearing or scissor-action causes no perceptible shock, and the small wear on the knife is immaterial, as by advancing it towards the impeller, and causing the blades of the latter to bear lightly against it, a keen edge is maintained by their grinding action without need to stop the pump. In the outer casing is cut a shallow spiral groove, through which is carried away with the ejected pump fluid any matter which may tend to become jambed between the edges of the impeller and the casing. Among the materials passed indifferently by actual pumps (8-inch diameter suction) may be mentioned paper, cotton waste, long pieces of rope, blocks of wood, shavings, corks, clothing, bricks, stones, and dead animals. In the course of these tests, carried out at the Pulsometer Engineering Co.'s Works (Reading), the pump passed such matter as could not be satisfactorily screened, owing to the almost immediate choking of the meshes, however large, and though on occasions a solid plug of fibrous matter sufficient to almost block the suction pipe vanished down it, the pump continued unchecked after recovering from a momentary diminution of flow. After several hours of such work all

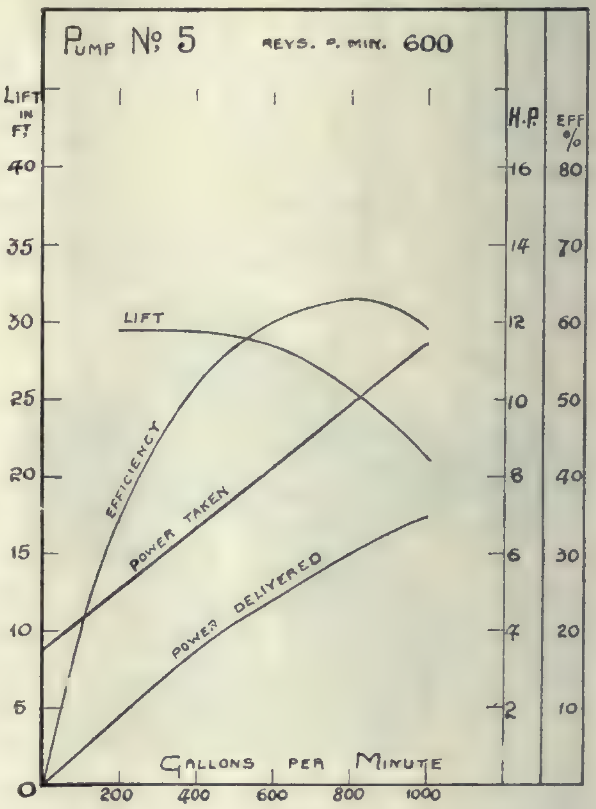


FIG. III.

internal parts were found to be clean and undamaged.

Apart from the "solid-eating" propensities implied by its name, the "Stereophagus" pump is so arranged that the impeller can be very finely adjusted, and so advanced towards the conical casing while actually at work, that the efficiency shall be a maximum. The difficulty of predetermination of losses has been generally recognised, and although it is possible from a few tests on a given pump to predict its performance under other conditions, as pointed out by the author in a previous record of such experiments,* the actual adjustment of the pump for *best* performance is another matter.

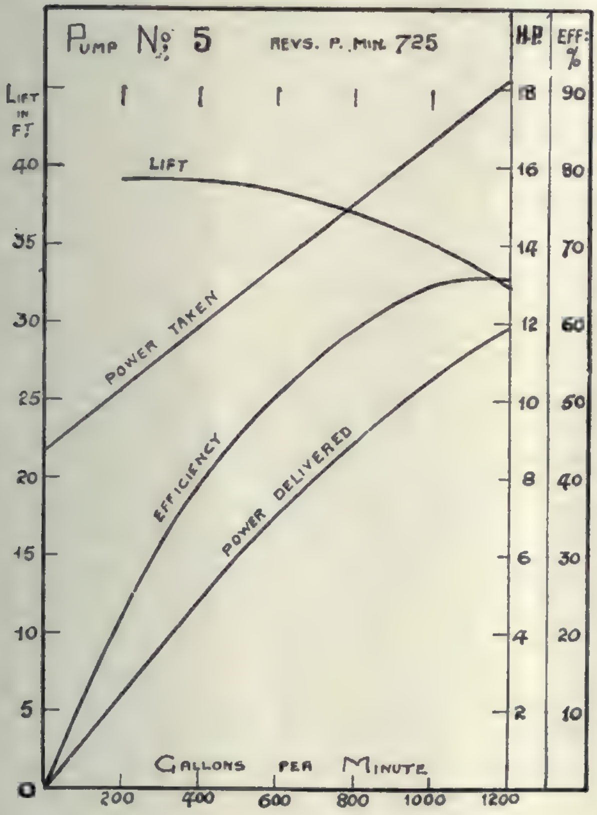


FIG. 4.

The falling off in efficiency, due to wear of the working surfaces by sand or grit in the fluid by an ordinary centrifugal pump, is inevitably considerable in the course of time, but the depreciation of the efficiency of a new pump in this way has been considered a necessary evil. The above simple remedy, brought about by a special adjustable thrust bearing, will both lengthen the life, and greatly increase economy in running.

The long and well-balanced bearing supporting the impeller shaft on the side remote from the inlet only is a special mechanical feature of the construction.

The "Stereophagus" pump is now fitted with a self-governing controller, specially designed for its use with an electric motor. By means of this the rise and fall of the water levels at suction and delivery cause the motor and pump to run at the speed most economical to the hydraulic conditions existing at the moment.

An automatic motor starter operated by the water levels forms a distinct part of this apparatus, and by means of this the pump can be relied upon to work intermittently as occasion demands, the most economical speeds being automatically secured by the controller proper, subsequently to the starting up.

This apparatus being entirely self-operating over a large range of discharge and head, the need for supervision of pump and motor installation is reduced to a minimum. Both pump and controlling gear form the subject of patents granted to or applied for by the Hon. R. C. Parsons, M.A., M.Inst.C.E. The results obtained from a "Stereophagus" pump, with 8-inch diameter inlet, on test, are given by the curves of Figs. III. and IV., showing an efficiency even at the low lift of 12 feet of 66 per cent.

PERSONAL AND OTHER NOTES.

On the recommendation of the Livesey Memorial Committee, the University Council has appointed Mr. John William Cobb, B.Sc., to be Livesey Professor of Coal, Gas, and Fuel Industries, from the end of the present Academic year, at the Leeds University, when the Chair will be vacated by Dr. W. A. Bone, F.R.S., who has accepted the Professorship of Fuel and Refractory Materials at the Imperial College of Science and Technology.

Steps have been taken by the Royal Society, in association with the Royal College of Surgeons of England, to form a Committee which will issue an appeal to provide a memorial to the late Lord Lister.

We regret to announce the death of Professor R. Frühling, who died on April 24th, aged 71. In 1872, he founded a School for Sugar Industry at Brunswick, was the author of text-books on analysis of sugar production and of soils, and editor of Stammers' "Pocket Book of Sugar Chemistry," since 1894.

Institute of Chemistry.

PASS LIST: APRIL EXAMINATIONS, 1912.

Of 15 candidates who presented themselves for the Intermediate Examination, 6 passed: L. M. Clark, A. L. vidson, F. C. Guthrie, B.A. (Cantab.), J. T. Janson, B.Sc. (Lond.), T. S. Jones, B.Sc. (Lond.), and D. A. Legg. Of 25 candidates who presented themselves for the Final Examination, 15 passed. In the Branch of Mineral Chemistry: A. M. Bailey, H. W. Gill, B.Sc. (Lond.), D. McDonald, B.Sc. (Lond.), A. H. Maude, and C. R. Robson; in the Branch of Physical Chemistry: F. W. Atack, B.Sc. Tech. (Manc.); in the Branch of Organic Chemistry: G. McL. Carruthers, R. B. Croad, J. R. Douglas, A.R.C.ScI., A. J. Hale, B.Sc. (Lond.), D. Hamilton, J. Porter, and A. Rayner, B.Sc. (Lond.); in the Branch of the Chemistry of Food and Drugs, and of Water: L. E. Campbell, B.Sc. (Lond.), and E. Hill, A.R.C.Sc. (Lond.).

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* "Experiments on Centrifugal Pumps" (Davis & Harding), *The Engineer*, August 27th, 1909.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By Emil Hatschek.

CHAPTER V.—(*Continued.*)

The organic emulsoids are very numerous and extremely important, including, as they do, most of the proteids, such as albumin, casein, gelatine; a number of carbohydrates as starch, agar, the gums, cellulose and its various nitro- and acetyl-derivatives; the soaps, etc. It is impossible within the limits of these papers to do more than to select a few typical substances, and to develop a few general points of view to which their extremely varied behaviour becomes referable.

Two of these may usefully be considered together, viz., gelatine and agar. The former is a proteid, while the latter is a mixture of carbohydrates, the most characteristic of which is d-galactan. Both gelatine and agar, when immersed in cold water imbibe large quantities and swell, until an equilibrium is attained. On heating, they dissolve to sols, the temperature necessary to effect this being 25°—35° for gelatine, according to the concentration, and about boiling point for agar. On cooling these sols set to jellies, the setting point for gelatine being a few degrees lower than the "melting point," whereas the agar sol can be cooled to about 35° before setting. The process is completely reversible, but the gels have to be heated to original temperatures, to be transformed into sols again. Agar is thus a very striking example of the phenomenon of hysteresis, as the sol, once formed, does not gelatinise until cooled to about 35°, whereas the gel is not re-transformed into sol unless raised to a temperature nearly 70° higher. A similar, but very much slighter, hysteresis, is noticeable in the case of gelatine. As in the case of silicic acid the transformation is quite continuous, that is (with the same reservation regarding the difficulty of measurements in the neighbourhood of the setting point) the viscosity increases continuously as temperature falls.

The viscosity of gelatine sols has been the subject of careful and important investigations, particularly by Garrett. These tend to show that a gelatine sol, unlike a homogeneous liquid, has not a definite constant viscosity at a given temperature, but that the viscosity varies with the velocity of shear, and alters with time if shearing, even at constant velocity, is continued. Without entering into details of these investigations, which still present many difficulties, it may be said that the behaviour of the sol is inexplicable, except on the assumption that it is a system of two fluid phases, or, in other words, that it consists of drops or globules having a high gelatine content, in a continuous phase which is a dilute solution. The process of sol formation on this assumption becomes an extension of the process of swelling by imbibition, accompanied by disintegration.

CHAPTER VI.

An entirely different behaviour is shown by the albumins, which are perhaps the most important among the emulsoids, and have received an amount of investigation commensurate with their importance. As their type neutral albumin prepared from white of egg may be taken. This is soluble in water at ordinary temperature, and does not form a gel either with increasing concentration or on cooling. On the other hand, it shows a phenomenon we have not so far encountered: it coagulates irreversibly on heating to about 60°. The temperature at which this change occurs may be altered by the addition of salts, and can—as has been shown by Pauli and Handowsky—be raised so much by the addition of a thiocyanate that the sol does not coagulate even at boiling point.

In close connection with this property of the albumin sol is its behaviour to salts in the cold, On the addition of salts in suitable concentrations the albumin sol becomes turbid, and the albumin finally settles out in flocculent masses. The coagulum, however, shows different characteristics with different salts, and these, if for the moment we consider only the cation, divide themselves into three groups. The salts of the alkalies and of magnesium produce coagulation or "salting out" only in great concentrations, and the process is *reversible—i.e.,* on dilution or removal of the salt the albumin again goes into solution. The salts of the alkaline earths salt out in similar concentration, but the precipitate becomes insoluble on standing even for a short time; while, finally, the salts of the heavy metals salt out irreversibly even in low concentrations.

If we now consider, instead of a variety of salts with different cations, a series having the same cation but different anions, we become acquainted with a sequence of the greatest importance, which was first discovered by Hofmeister in his investigations on egg albumin, and is generally called after him. Some of his results are given in the following table, which shows the concentration in moles per litre of the sodium salts of various acids necessary to salt out the same albumin sol at 30°—40°.

Citrate	0·56
Tartrate	0·78
Sulphate	0·80
Acetate	1·69
Chloride	3·62
Nitrate	5·42
Chlorate	5·52
Iodide	Do not salt out in saturated solution.
Thiocyanate	

This series refers to the neutral albumin investigated by Hofmeister. A further very striking fact was shown by Pauli: the effect of the series is reversed in faintly acid sols, in which the iodine and thiocyanate have the greatest, and the citrates and tartrates the least action.

At first sight no explanation whatever of these features suggests itself. The obvious temptation is to look for a chemical action, and the order in which the acids follow one another—tribasic, dibasic and monobasic—gives some plausibility to that view. It becomes, however, quite untenable when we study the effect of the series on other emulsoids besides albumin, for instance, on substances as dissimilar chemically as gelatin and agar. As far as a comparison is possible this is parallel with the effect on albumin. The addition of citrate or tartrate to a gelatin or an agar sol raises the setting point and produces a stiffer gel; the addition of an iodide or a thiocyanate lowers it and leads to the formation of gel of slighter consistence. With sufficient concentrations of thiocyanate a gelatin or agar sol may be entirely prevented from setting to a gel at ordinary temperature. The viscosity of the sols is affected in the same sense. The only general view which coordinates all these phenomena is this: they are all various manifestations of a change in the distribution of water between the two phases, and the salts of the Hofmeister series affect this distribution, and do so by altering the compressibility of water. The solution of most emulsoids proceeds with contraction—a point which we shall discuss in greater detail when dealing with gels—and the view, propounded and supported with a great deal of evidence by Freundlich, that the effect of the Hofmeister series is closely connected with changes in the compressibility of water, is therefore entirely rational.

The emulsoids described so far, namely gelatin and agar on one hand and albumin on the other, are of two different types as regards their behaviour at different temperatures. The first named set to gels, without separation of water, below certain temperatures, while the latter coagulates irreversibly above a certain limit. A very large number of emulsoids do not exhibit either of these characteristics: they neither form gels at low temperatures nor coagulate on heating. This class contains practically all the emulsoids in solvents other than water, and many substances which form sols with water, such as the gums, starch, etc. Another member of this group is casein, which is peculiar in being insoluble in water alone, but soluble in weak solutions of alkali. The alkali-casein sols are in many ways very typical emulsoid sols: they show a very rapid increase of viscosity with falling temperature and increasing concentration, without either gel formation or heat coagulation. The effect of the Hofmeister series, as far as it has been examined, is the same as on other sols, and casein also shows slight contraction in solution.

A similar behaviour, that is an absence of discontinuity at either extreme of temperature, is shown by gum arabic and similar sols. Gum arabic can be "salted out" by great concentrations of sodium chloride or other salts, the whole effect being again obviously due to removal of water from one phase into the other.

Among the sols with continuous phases other than water the most interesting are undoubtedly the sols of cellulose and of its nitroderivatives, which have assumed great industrial importance in recent years, as the materials for the production of artificial silk, etc. As is well known, cellulose is dissolved by cupric oxide-ammonia solution, forming a typical emulsoid sol of very high viscosity, from which the cellulose can be precipitated as a coherent gel by neutralising the solvent with acid. Cellulose is also gradually dissolved by a 50% zinc chloride solution at about 60°, and this sol is characterised by an even higher viscosity than the cuprammonium sol. The nitro-celluloses—collodion and gun-cotton—form sols with a whole series of solvents, such as glacial acetic acid, acetone, ether-alcohol, amyl acetate, etc., all of which show the typical emulsoid properties: very high, but inconstant, viscosities, and slight turbidity or opalescence. With one of these sols, the acetic acid collodion, we are already familiar as a material for making ultra-filters: these sols leave a coherent gel like mass when the acetic acid is removed by water. Many of the other nitro-cellulose sols leave coherent films on drying, the properties of which can be modified by various additions, such as castor oil or camphor, a point which will receive further attention in the discussion of gels.

No special reference has so far been made to the electrical condition of the emulsoids, but from what has been stated in regard to salting out and related phenomena it is obvious that there is a profound difference between the suspensoids and emulsoids in this respect. The electric properties of the latter are not nearly as unambiguous as those of the former, and are affected, or, indeed, determined almost entirely by the reaction of the dispersion medium—*i.e.*, the concentration of H or HO ions. This point also has been investigated chiefly in connection with albumin sols, especially by Pauli and his pupils. He showed that albumin freed as far as possible from electrolytes by prolonged dialysis and by freezing and thawing did not travel in the electric field, *i.e.*, was not charged. In the presence of small concentrations of acid it assumes a positive charge, and in the presence of alkali a strong negative one. The conditions, however, are much more complicated than in suspensoids, as chemical reactions between bodies as sensitive as albumin and the added electrolyte must be expected, while they are not at all probable in many suspensoids.

(*To be continued.*)

CHEMICAL SOCIETY RESEARCH FUND.

A meeting of the Research Fund Committee will be held in June. Applications for grants to be made on forms which can be obtained from the Assistant Secretary, must be received on, or before Monday, June 3rd, 1912.

All persons who received grants in June 1911, or in June of any previous year, whose accounts have not been declared closed by the Council, are reminded that reports must be in the hands of the Hon. Secretaries not later than Saturday, June 1st.

REVIEWS OF BOOKS.

"THE CHEMISTRY OF THE RUBBER INDUSTRY."

By Harold E. Potts. CONSTABLE & CO., LTD., London, 1912. Pages 153+viii, including Index. Chapters VI. Price 5s. net.

The influence of colloidal chemistry on modern industry is seen in the fact that the first part of this book is devoted to a general, and so far as it goes, satisfactory account of the known properties of colloids. The statement that all bodies may ultimately be obtained in both the colloidal and crystalline state (even rubber) is one which may not be fully justified from our present knowledge. There is little indication at present that such substances as rubber, or cellulose, will be prepared in the latter state, and it is perhaps a little premature to talk of rubber as a body which can in any way be compared with, say, sodium sulphate. With this reservation this part of the book is certainly useful as a general introduction to the salient features and properties of colloids, although there is nothing mentioned which will not be known to everyone connected with the scientific side of this industry.

The next section deals with the question of raw rubber, and the coagulation of the latex by the methods adopted at the present time. The reason for the presence of the latex in the tree is briefly discussed, and the view of Harries that it forms a food reserve to be broken down into sugar, as occasion requires, seems to be yet unproved. The alternative suggestion that the latex is present to protect the tree against wounds is perhaps even less reasonable in view of the immense quantities present. The presence of proteins and resins, which play such an important part in the value of the rubber for commercial purposes, is but briefly touched on in this section. The past superiority of Para is expressed in its uniformity and "nerve"—an expression which is as difficult to explain, as is its similar use in the silk industry. Its presence denotes a certain superior elasticity and firmness in both cases.

The classification of the methods of coagulation follows that of Spence, so that it need not be dealt with in detail. The conclusions drawn by Marckwald and Frank that the influence of the method of coagulation is of far more importance than the source of the latex, will not perhaps be generally accepted by practical men. The latex of Kickxias is kept as such by a peptone acting as a protective colloid. As this is not coagulated by acids, or boiling, as in the case of the proteids, special treatment is necessary, formaldehyde being used in practice. The presence of coloured bodies causing discolouration is ascribed to the presence of ferment-like bodies or enzymes.

Tackiness, which is the result of a kind of disease (partly bacterial), is stated to be closely connected with insufficient coagulation. Uniformity is seemingly influenced by other conditions than coagulation, however. It has been observed that the latex collected from different parts of a forest differs greatly in specific gravity and rubber content. After coagulation, the washing process to clean the product is an important one, and great care has to be taken in the subsequent drying operations.

It is rightly pointed out that even to-day it is very unlikely that the pure hydrocarbon rubber has even been obtained from the natural product. The removal of resins and proteins is, judging from operations with other colloids, an almost impossible task. The classic work of Harries on the constitution of the rubber molecule $C_{10}H_{16}$ is discussed at some length.

The following section deals with analysis of raw rubber, and contains a fairly full account of the different methods in vogue to-day.

In the subsequent operation of "mixing" we pass from the exact to the empirical, and here have an example of the value of practical experience in manufacturing operations, for it is almost impossible to rely upon any analysis as a guide, where so many other properties than those of mere chemical composition are involved. It is at this stage that waste rubber, reclaimed rubber, and rubber substitutes, etc., are added. The number of the latter is legion, and many would undoubtedly be deleterious if used in practice. Whether these organic substitutes should under any conditions be employed in a product which is sold as rubber is still an open question. The fact that this is done certainly indicates that their value is a definite one to the manufacturer, if not to the user.

Vulcanisation is next considered, and it is clearly pointed out that although rubber was actually used before the advent of this controlling operation, this invention may to a great extent be accounted as the cause of its extended use. Finally, the question of vulcanised rubber and its analysis is treated in fair detail.

It will be seen that this work presents to the general reader a satisfactory account of the india-rubber industry. The author has stated in the preface that it was his intention to present the subject, not for the sake of technique, but for its bearing on chemical work. Also that he has refrained from filling the work with illustrations which rightly belong to the advertisement columns of the technical press. He has certainly succeeded in producing a very readable book, and one which has a general usefulness, even in these days of the multiplication of text books.

"METHODS OF AIR ANALYSIS." By J. S. Haldane. CHARLES GRIFFIN & Co., Ltd., London. 1912. Pages 130 + viii, including index, with 24 Illustrations, including 1 Plate. Price 5/- net.

This work contains an account of "more or less original methods" of dealing with the analysis of air, mine air, products of combustion and the like; more particularly from the point of view of experimental work in Physiology and Hygiene. It also deals with the estimation of dust in air, including that of lead. The illustrations are clear and easily followed, and many points are dealt with, which the ordinary text-book does not touch on. As might be expected from the author's experience, this small work is a good deal more important than its size would indicate, and should be found in the reference library of all general laboratories. Very definite and clear instructions are given as to the practical carrying out of the tests mentioned.

Books Received.

"LECTURES ON CELLULOSE," by C. F. Cross. Published by the Institute of Chemistry, 1912. Pages 52. Price 2/6 for non-members.

"THEORIE UND PRAXIS DES MAHLENS," by Clayton Beadle and Henry P. Stevens. Translated into German by Carl Franck. Otto Elsner Verlagsgesellschaft, Berlin, 1911. Pages 292. Chapters XVIII., including illustrations. Price 2 marks.

"BLEACHING AND DYEING OF VEGETABLE FIBROUS MATERIALS," by Julius Hübner. Constable & Co., Ltd., London, 1912. Pages 434+xiii, including Index. Parts 18, with 96 Illustrations. Price 14/- net.

"ALLEN'S COMMERCIAL ORGANIC ANALYSIS." Vol. VI. Amines, Tar Bases, Vegetable Alkaloids, Coffee and Cocoa. Edited by W. A. Davis and S. S. Sadtler. Contributors: W. H. Glover, T. A. Henry, F. O. Taylor, R. W. Tonkin, F. H. Carr, S. P. Sadtler, C. E. Vanderkleed, O. Chick, E. Horton, J. J. Fox, R. J. Sageman, R. Whymper. J. & A. Churchill. Pages 721+ix. Price 21/- net.

"ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA, CHEMICAL, PHYSICAL AND TECHNOLOGICAL." Vol. I., 1910. Pages 727+xxxix. J. & A. Churchill, London. Price 21/6 net (paper); 24/- net (cloth).

"CHEMICAL WORKS: THEIR DESIGN, ERECTION, AND EQUIPMENT," by S. S. Dyson and S. S. Clarkson. Scott, Greenwood & Son, London, 1912. Pages 207+ix, including Index and Appendices. Chapters XI., including 80 Illustrations and 9 Plates. Price 21/ net.

"PUBLIC HEALTH CHEMISTRY AND BACTERIOLOGY," by David McKail. Simpkin, Marshall, Hamilton, Kent & Co., Ltd., London, 1912. Pages 409+iv, including Index and Appendix. Chapters XVIII. Price 6/6 net.

"INORGANIC CHEMISTRY FOR BEGINNERS," by Rt. Hon. Sir Henry Roscoe and Joseph Lunt. Macmillan & Co., London, 1912. Pages 256+x, including Index and Appendix. Divided into two parts, with numerous Illustrations. Price 2/6.

"A DICTIONARY OF APPLIED CHEMISTRY," by Sir Edward Thorpe. Longmans, Green & Co., London, 1912. Vol. II. Pages 786+viii. Numerous Illustrations. Price 45/- net.

"THE ANALYST'S LABORATORY COMPANION," by Alfred E. Johnson. Fourth Edition. J. & A. Churchill, London, 1912. Pages 161+vi, including Index. Price 6/6 net.

NEW METHODS OF ANALYSIS.

AUTOMATIC ANALYSIS.

By CHARLES A. KEANE, D.Sc., PH.D., F.I.C.

(Continued from page 141.)

This float is attached to a pen which is caused to travel downwards on the chart in proportion to the upward movement of the float. If the gas be free from carbon dioxide the float will, of course, receive a full 20 c.c. (20%) of the sample, and will then travel the full length of the chart from the 20% line, which is at the top, to the zero line at the bottom; any absorption of carbon dioxide will cause a decreased volume of gas to be delivered to the float and a proportional indication of the content of carbon dioxide will thus be obtained.

The intake of successive samples of gas is controlled by the water supply which enters the instrument at 8, and after passing a small injector at 9, enters the fall-tube 74 and compresses the air above the water-level in the vessel 82; this pressure is transmitted through the tube 78 to the vessel 87, which is filled with a mixture of one part of glycerine to two parts of water. From this vessel the pressure is further transmitted through each of the connected branches (68, 76 and 77) until the water in the burette (67) reaches the mark 71; at this stage the water also reaches the top of the syphon 47, which then commences to operate, whereby the pressure on the lower vessel 87 is removed, so that the liquid in the connected branches returns to its original level. The partial vacuum thus created serves to draw in the sample of gas from the pipe 5, through the tube 49 into the burette. The flow of the syphon then stops and the cycle of operations is repeated. With the next filling of the burette with the liquid from the vessel 87, the gas sample is transferred to the caustic potash vessel 94, and thence to the floats (27 and 18), which then operate as described above.

The Simmance-Abady Combustion Recorder.[1]

The method of analysis with this instrument, which is distinguished from the "Sarco" by all parts being made of metal instead of glass and by its simpler construction, consists in automatically aspirating the sample

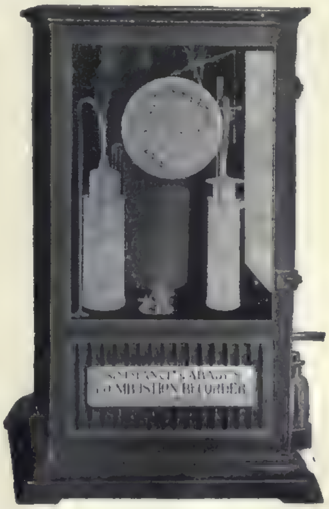

FIG. 3.

of gas from the connection with the flue by means of a float, passing it through a solution of caustic potash, and measuring a portion of the residual gas.

The actual apparatus, of which there are several forms, is shown in Fig. 3; Fig. 4 gives a diagrammatic representation of the parts. The water, which serves as the motive power, passes from *x* into the tank *a*, whereby the float *b* is raised; when this reaches the top of the tank an automatic syphon *g* is set in action and the tank emptied, so that the float, which is heavily weighted, falls, and raises the float *d* in the adjacent tank. At the same time, the syphon actuates a balance valve *h*, so as to permit of the gas sample being drawn into *d* from the pipe *p*. The cycle is then reversed. The syphon is automatically shut off, water again enters the tank *a*, raises the float *b*, whereby the gas in *d* is discharged through a solution of caustic potash contained in the vessel *m*, to the float-recorder *j*. The float *d* has a capacity of 160 c.c., and of this volume 100 c.c. are transferred to *j*, if no carbon dioxide is absorbed, gives it the zero reading on the scale *n*; any absorption of carbon dioxide is thus proportionately recorded with each movement of the float.

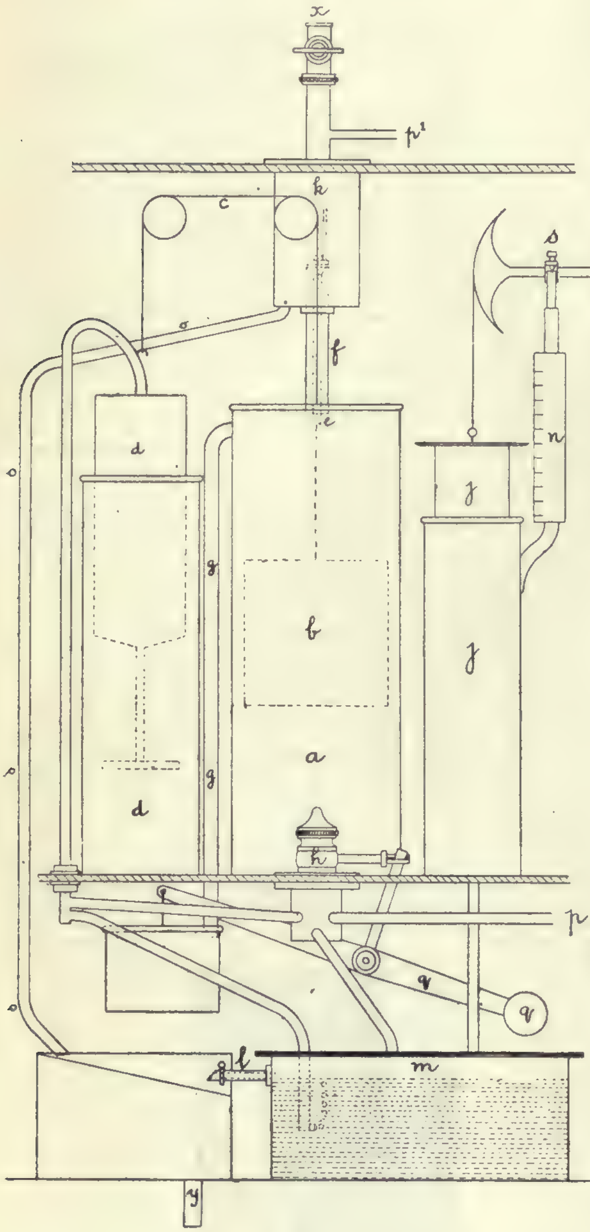

FIG. 4.

A modified form of this instrument is made for the estimation of sulphur dioxide, in which all the parts, except the float-recorder, are made of glass.

This apparatus has been recently adapted for the estimation of carbon monoxide by combining it with the method devised by L. Levy for the estimation of carbon monoxide by oxidation, with iodine pentoxide, to carbon dioxide. (*Cf. J. Soc. Chemical Industry*, 1911, p. 1,438; *J. of Gas Lighting*, 1911, p. 817.)

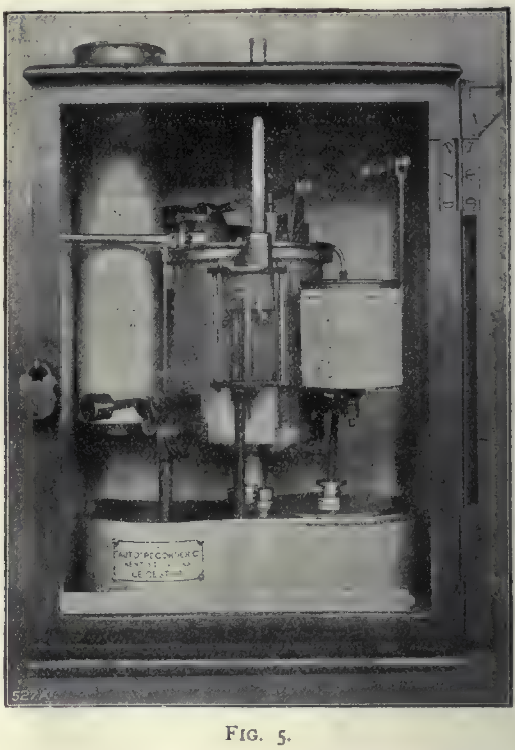

FIG. 5.

The "Auto" Carbon Dioxide Recorder.[2]

In this instrument the parts are all made of metal and are readily detachable for cleaning purposes. Fig. 5 represents the apparatus, and Fig. 6 a diagram of the working parts. The water supply enters the instrument at *B*, and passes through the tank *A* to the central chamber *D*, which has a capacity of about 2,000 c.c. This chamber contains two measuring vessels, *N* and *U*; the former has a capacity of 100 c.c. plus the volume of the connecting passages between this measuring vessel and the absorption vessel *S*, whilst that of the latter is 4 c.c. greater, this difference being requisite to give a zero reading when working on pure air. When *D* is filled, the water overflows through *E* to the vessel *G*, whereby *D* is emptied by means of the syphon *J*. As the level of the water in *D* descends the sample of gas is drawn in at *L* through the water-seal *M* and the tube *E*. The measuring vessel *N* is simultaneously filled with a portion of the sample. With the next cycle the chamber *D* and the vessel *N* are refilled with water and the contents of the latter transferred to the vessel *S*, in which the contained carbon dioxide is absorbed by a solution of caustic potash. With the next descent of the water in *D* the gas from *S* is syphoned into the measuring vessel *U*. Owing to the relative capacities of the two measuring vessels, the vessel *U* will be filled to within 4 c.c. by the gas from *S* if no carbon dioxide has been absorbed. In case of absorption, however, the volume will be less, and this decrease is made up by the drawing in of air from under the bell *V*. This added volume, which is obviously the equivalent of the carbon dioxide absorbed, is recorded by a pen attached to the bell *V*.

It is to be noted in this instrument that the sample of gas is drawn through water which may necessitate the introduction of a correction in the estimation, especially when marked variations in temperature occur.

The Bi-Meter Carbon Dioxide Recorder.[3]

The absorption of carbon dioxide in this instrument is measured differentially by means of two meters, which are attached to a recording mechanism which is so arranged that it records intermittently after a certain volume of gas has been drawn through the apparatus. About $1\frac{1}{2}$ cubic feet are aspirated per hour, during which period up to 25 successive records can be obtained. The parts are made of metal, and there are no rubber connections. The measurement of the gas-volumes, before and after the absorption of the carbon dioxide, by means of meters necessitates the avoidance of a liquid absorbent, for which powdered lime is substituted; this is used in a series of layers mixed with wet wood shavings, through which the gas is aspirated. To adjust the rise of temperature in the gas, due to the absorption, the sample is passed through temperature equalisers, which consist of a series of water-cooled pipes, both before and after the absorption.

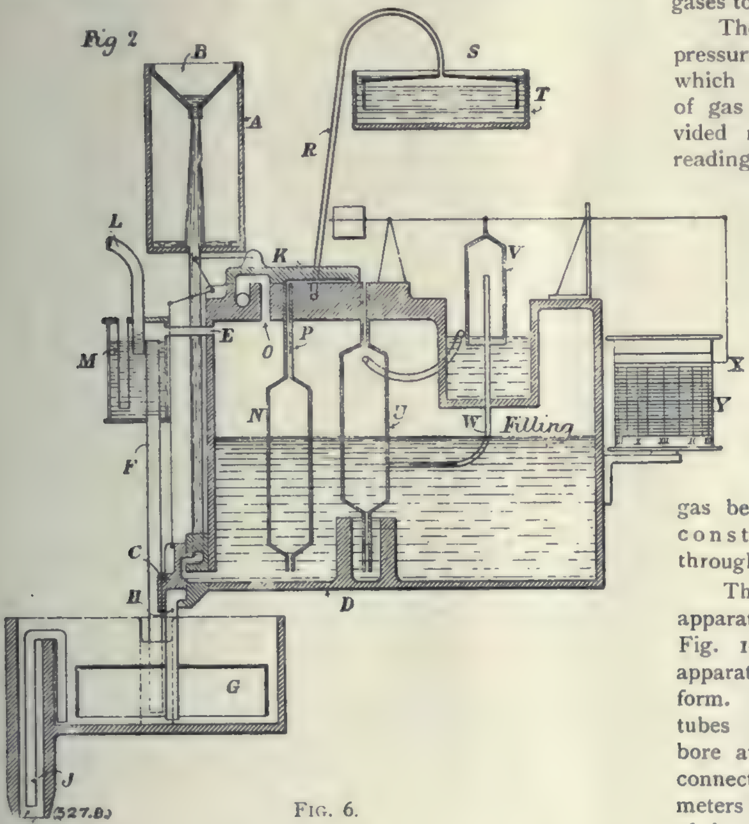

FIG. 6.

The apparatus is shown in Fig. 7 and diagrammatically in Fig. 8. The gas is drawn in at *A* by means of the water-aspirator *B*, and then passes through a temperature equaliser contained in *K* to the meter M_1. From this meter it is drawn through the absorption vessel *E*, thence into the second temperature equaliser, which is also enclosed in *K*, and finally measured in the meter M_2, whence it escapes into the air.

The gas meters are filled with oil, and are so adjusted that M_2 moves about 4% slower than M_1 when no carbon dioxide is absorbed; this difference in speed depends upon the difference in the level of the oil in the two meters. An absorption of carbon dioxide reduces the volume of gas which passes through the second meter, and this difference is recorded by means of the differential gearing with which the meters are connected.

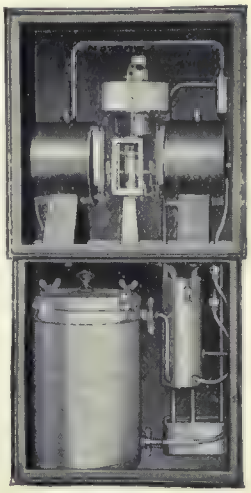

FIG. 7.

The Autolysator.[4]

As stated above (April No., p. 140), the Autolysator, designed by Strache, Johoda and Genzken, differs from the other forms of automatic apparatus by giving a continuous instead of an intermittent record of the carbon dioxide content of the gases to be analysed.

The sample is drawn by water suction of constant pressure through two similar capillary tubes, each of which is connected with a manometer. A constant flow of gas is thus obtained through the two tubes, and, provided no absorbent be interposed, the two manometer readings will necessarily be the same. By the interposition of an absorbent between the capillary tubes a means is introduced for the determination of the absorbed gas by virtue of the proportional difference in pressure that will arise and be indicated on the manometer, provided the flow of gas be so regulated that a constant volume passes through the apparatus.

The arrangement of the apparatus is shown in Fig. 9; Fig. 10 shows the actual apparatus in its most recent form. K_1 and K_2 are capillary tubes of glass of identical bore and length, which are connected with the manometers M_1 and M_2 respectively. *A* is the absorption vessel, which is filled with an easily detachable bucket charged with soda lime, placed above a thin layer of calcium chloride. The volume of gas drawn through the apparatus is controlled by means of an adjustable regulator *H*.

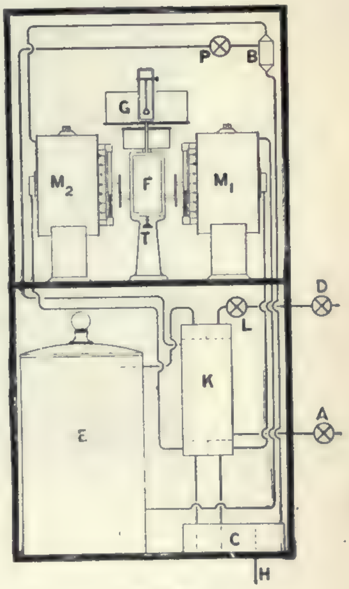

FIG. 8

The gas sample is drawn in at *E*, through the capillary K_2, and the pressure recorded on the attached manometer M_2; it then passes through the absorbent contained in *A* and the second capillary K_1. In absence of carbon dioxide both manometers will stand at the zero point of the attached scales, as the same volume of gas is drawn through both capillaries in a unit of time; but any absorption of gas by the soda lime will necessitate a greater volume of gas being drawn through the tube K_2 than through

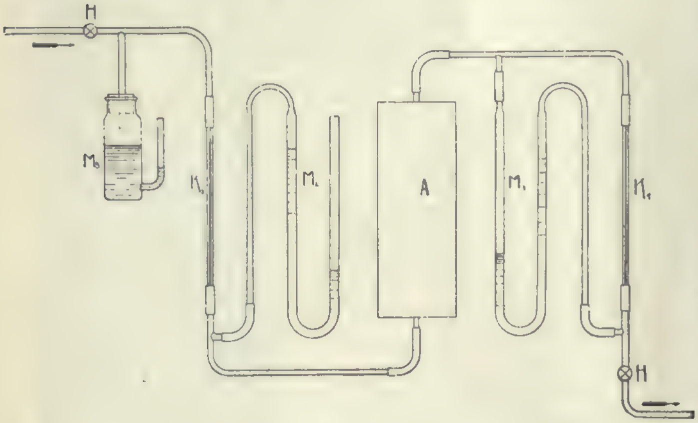

FIG. 9.

K_1, as the flow through the latter is maintained at a constant rate. A difference in pressure is thus produced which is recorded on the scale of the manometer M_2. For the recording of the scale-readings the capillary tube K_2 is so connected with an enclosed float that the pressure of the gas before and after passing the capillary is reproduced on either side of the float; a pen is attached to the upper end of the float and its movements thus recorded on a revolving drum in the usual way.

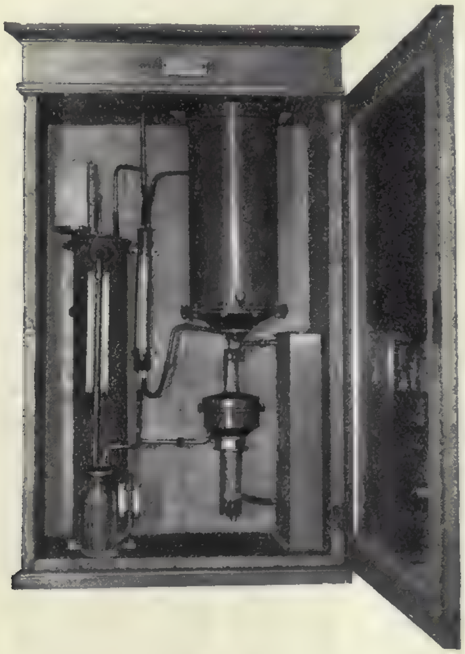

FIG. 10.

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[1] Made by Messrs. Alexander Wright & Co., Westminster, London, S.W.

[2] Made by the "Auto" Recorder Co., Kent Street Works, Leicester.

[3] Made by the Cambridge Scientific Instrument Co., Cambridge.

[4] Supplied by A. Favre & Co., 21 Mincing Lane, London, E.C.

COMMERCIAL AND GENERAL NOTES.

A New Waterproofing Material for Fishing Nets, etc.

According to a statement made by the Secretary of the Danish Fishery Association (Dansk Fiskeriforening), an interesting invention has been made by the technical director of a large chemical firm in Copenhagen. This gentleman has solved the problem of making fishing nets, tents, awnings, etc., practically everlasting or, at least, of lengthening their period of usefulness considerably. It is well known that fishing nets, even when new, are quickly destroyed by microscopic fungi which spread rapidly under the favourable influences of moisture, fish, refuse, etc. It was, so far, impossible to prevent this effectively, as even the application of creosote or tar had no lasting effect. Experiments with the impregnation of the yarns with certain chemicals (such as solutions of arsenic, tannic acid, etc.) which would poison any bacilli or fungi, have been made and found only partly successful, inasmuch as the chemicals protected the yarns only a short time, and the impregnation had to be renewed rather frequently. The new substance which has been brought out under the name of "Cuprinol" is said to be insoluble in water, and one impregnation of the yarns is sufficient to protect the articles for a considerable time. A leading chemist in Copenhagen prophesies a great future for the invention, especially in countries where the fishing industry is of importance. The results of the experiments which are now being made by the Danish army and navy are looked forward to with interest. "Cuprinol" will be shown at the forthcoming Scandinavian fishery exhibition in Copenhagen.

A New Substitute for Jute.

Jute fibre, which is frequently utilised to serve as a substitute for wool, silk, or any other valuable textile fibre, will, in its turn, have to face the competition of a new substitute much cheaper than itself. It is produced after a German patented process which is said to be a modification on that for the manufacture of paper yarn. Owing to the incorporation of cotton waste the new fibre is much stronger than paper yarn and is easier to weave. The well-known German aristocrat, Furst Henckel von Donnersmark, who is closely connected with the manufacture of artificial silk after the viscose method, is interested in the working of the new patent. Experiments which have been made with the manufacture of sacks and packing materials have had very satisfactory results. The price of the articles is nearly 20% lower than that of jute bagging, while leaving to the makers a profit of 100% under the present working conditions. This profit could, of course, be increased if the manufacture would be taken up on a greater scale, but whether this will be done remains to be seen.

New Perfumes for Soaps.

The manufacture of soaps, either by the classic Marseilles process or by the new processes (boiling with a weak caustic lye) demands perfumes of a very special tenacity and of absolute stability against alkaline agents. For this reason a considerable market has been opened for several substances belonging to the series of ether oxides, either single or mixed.

One of the most interesting, says *La Perfumerie Moderne*, is unquestionably the artificial oil of geranium. It comes into serious competition with the oils of Bourbon and of Africa. It is oxide of phenyl which melts at 28°C and boils at 253°C. Melted it has a fluorescent appearance, and, thanks to its ether oxide function, it is very stable. It is mixed with oils of citronella, palmarosa, clove and vetiver, even with other chemical perfumes, such as formiate of citronellyl and terpineol, so as to obtain a large series of odour, all based on geranium. It is usually estimated that 100 grammes of oxide of phenyl have, as regards intensity, a value equivalent to a kilogramme of the Bourbon oil without having, it must be admitted, the same delicacy, but altogether sufficient for the production of ordinary goods, or for disguising certain odours of rancidity originating in the fatty substances used.

Earnings of Continental Chemical Firms.

The report just issued by the Griesheim Electron Chemical Works, Frankfort-on-Main, the largest German firm of colour-makers outside the two principal groups, discloses a net profit of 2,959,046 marks, against 2,967,651 marks last year, and again proposes a dividend of 14%. The capital is 14 million marks, and it is being increased to 16 million marks. The Chemische Fabriken vorm. Weiler-ter Meer, Uerdingen, is again paying 12%. The present capital is 6 million marks against 5 million marks last year.

The Outlook for Artificial Silk.

According to the *Chemnitzer Tageblatt*, the outlook for artificial silk is very promising. Since October of last year no transactions of consequence have taken place because all the leading manufacturers have sold their production for 1912, and are, therefore, unable to accept further orders. The current year promises to see a further great increase in the consumption of artificial silk. The German centres of the industry report a very active demand, and the weaving industry is absorbing enormous quantities of the article. An unsatisfactory feature of the market is, however, the low prices with which the manufacturers had to be content when booking their orders last year. In spite of the pronounced scarcity of the material they are at present unable to profit by an increase of prices as they have nothing to sell. The unexpected rise of the spirit prices last autumn has diminished their profits considerably, and the recently announced further rise by 3 marks per hectolitre represents an addition of about 3½d. per kilo to the cost of making artificial silk.

A striking proof of the unprofitable nature of the business during the last year is furnished by the report just issued by the Glanzfaden Aktien Gesellschaft, Berlin, which discloses a net loss for the past year, the first complete working year of the undertaking, of 43,147 marks, against a net loss the previous twelve months of 11,917 marks. The company was formed in 1910 to work the Linkmeyer artificial silk patents. The capital is one million marks.

An Austrian concern, the First Austrian Glanzstoff Ges., reports a difficult year though paying a dividend of 10%, as before. The Austrian manufacturers are mainly hit by foreign competition and are agitating in order to obtain the protection of an import duty on artificial silk. This particular firm has been working the gun-cotton process but will shortly start manufacturing viscose silk in order to supply the weaving industry with better material.

A confirmation of the decided increase in the consumption of artificial silk in weaving is furnished by the Crefeld Chamber of Commerce. According to a statement made at a recent meeting of this body on March 30 last, the consumption of artificial silk by piece-goods manufacturers in the district of Crefeld (the centre of the German silk weaving industry) during last year amounted to 164,546 kilos, against 30,251 in 1910. The current year promises to show another increase.

The Austrian Chemical Industry in 1911.

As the making of chemicals is intimately connected with all branches of industry, commerce and agriculture, being dependent on them for the sale of its products, any boom or depression occurring in one or the other must, of a necessity, affect the chemical industry. For this reason, the development of the Austrian trade and the prosperous condition of the agricultural industry in 1911, reacted favourably on the trade of chemicals in general. On the other hand, the critical condition of the petroleum industry and the depression in the market for textile goods exercised a restraining influence on the sale and consumption of certain chemicals.

The Austrian makers of sulphuric acid had reason to complain of diminished consumption of their product in consequence of the slump in the petroleum industry and the competition of imported sulphuric acid. This latter, being largely a by-product of zinc-manufacture, is considerably cheaper than the home-made article. The keen rivalry of foreign makers of superphosphate, which is imported free of duty, acted unfavourably on the production and sale of Austrian fertilizers. The export of trade in chemicals was far more difficult than in previous years, and the prospects for the future do not seem very promising. Increased transport rates, growing taxation, higher wages and rising costs of raw materials threaten to put further difficulties in the way of the manufacturers of chemicals and hinder the development of the industry.

Free Admission of certain Fertilizers into Finland.

According to an order of the Imperial Senate for Finland, calcium cyanamide and calcium nitrate for fertilizing purposes may be imported free of duty until the end of this year.

The Danger of Celluloid to Home Workers.

The Ministry of Saxony has issued new regulations as regards the working or finishing of celluloid articles in private dwellings. In a statement accompanying the new regulations it is pointed out that the dangers of celluloid working are increased if the work is done in small rooms with bad ventilation. Apart from the inflammability of the material and its consequent danger to the workers who have no special protection against fire emergencies, there is the danger of poisoning by prussic acid which is being produced when burning celluloid. Experiments made by the Hygienic Institute of Leipzig have shown that the burning of 5 grammes of celluloid scraps in the open air produced about 0·05 grammes of prussic acid, a quantity sufficient to kill one person. The finishing of celluloid articles is largely done by women and children in their private dwellings where considerable quantities of this dangerous material are frequently stored. The manufacturers are, therefore, ordered to point out the dangerous nature of the work to the persons employed in home-finishing, and they are also forbidden to give out more than 6 kilos of material to any one family at a time.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

7619/11. J. H. EASTERFIELD and C. M. TAYLOR, Wellington, New Zealand. **Ketones.** Dated under International Convention, as 21 April, 1910.

The commonest process for preparing ketones consists of heating the calcium, barium or lead salts of organic acids to a high temperature. The applicants have found that in the case of the higher fatty acids, such as palmitic, stearic, brassidic, oleic, cerotic, montanic and melissic acids, a much better process is to heat the acid in contact with finely divided iron, taking care that the temperature does not far exceed the temperature of incipient decomposition of the acid. The heating is continued until the evolution of carbon dioxide has nearly ceased, and the crude product is purified by any of the usual methods for the purification of ketones. (2 claims.)

9174/11. J. H. THWAITES, Peterborough. **Treatment of Copper Liquors.** 13 April, 1911.

The application of zinc sulphide as a precipitant for copper in copper liquors presents certain advantages. According to the present invention, the zinc sulphide is used in the form of a mixture of barium sulphate and zinc sulphide, such as is obtained by precipitating a solution of zinc sulphate with barium sulphide. This product is used in manner substantially similar to that in which zinc sulphide has been used to precipitate the copper as sulphide from liquors containing copper, whereby zinc passes into solution and barium sulphate remains mixed with the precipitated copper sulphide. The mixture is oxidised to convert the copper sulphide into copper sulphate, and is then leached with water to extract the latter. The residue of barium sulphate is now converted into sulphide, and this is used to precipitate the zinc from the liquor from which the copper has been removed. This liquor must contain a dissolved sulphate which may be present as an original constituent of the liquor or may be added at this stage. The mixture of zinc sulphide and barium sulphate thus produced is then used to precipitate copper from another batch of liquor. (2 claims.)

9358/11. W. BEIMANN, Wakefield. **Ammonium Chloride.** 15 April, 1911.

The liquor which condenses from the volatile products obtained by carbonising coal, whether in gas retorts, coke ovens or gas producers, generally contains ammonium chloride, the recovery of which as such is rendered difficult or expensive owing to the large amount of water which must be evaporated before the ammonium chloride will crystallise. According to this invention, the water vapour in the volatile products from the retort, oven or producer is condensed fractionally, so that there may be obtained a liquor richer in ammonium chloride than the liquor obtained by condensing the water vapour as a whole. Such enriched liquor constitutes the first fraction or earlier fractions, and this fraction or these fractions are returned to the carbonising chamber as often as may be necessary, so that a liquor is finally obtained which is sufficiently rich in ammonium chloride to pay for evaporation. (2 claims.)

9462/11. H. A. VOEDISCH and P. KRIESMANN, Brantford, Ontario, Canada. **Leather Treatment.** 18 April, 1911.

Chrome salts are removed and recovered from leather, leather scrap or offal in the following manner:—The leather is first immersed in a bath of alkali hydroxide, such as sodium hydroxide, the strength of the solution being about 112 lbs. of alkali to 2,000 lbs. of scrap chrome tanned leather. The leather is kept in this bath for about two weeks, and is then placed in a bath of clear water for about a day and thoroughly washed. The leather is then placed in an acid bath of such an acid as is capable of dissolving the chrome salts formed in the scraps, the strength of the solution being about 76 lbs. of acid to 2,000 lbs. of leather scrap. In this bath the leather is kept for two or three days. The liquors of both the alkali hydroxide and the acid baths are mixed together. The resultant liquor is decanted and the precipitates are dried ready to be used again. (2 claims.)

10914/11. J. Y. JOHNSON, London. **Rubber Substitutes.** (Communicated by Badische Anilin und Soda Fabrik, Ludwigshafen-on-Rhine.) 5 May, 1911.

Compounds resembling rubber are manufactured by heating isoprene or a homologue thereof in the presence of a very small quantity of sulphur. (2 claims.)

12662/11. J. Y. JOHNSON, London. **Molybdenum nitride.** (Communicated by Badische Anilin und Soda Fabrik, Ludwigshafen-on-Rhine.) 25 May, 1911.

The usual process of preparing metallic nitrides from the corresponding oxides and nitrogen has hitherto been carried out in the presence of solid reducing agents. The communicants have found that they can obtain nitrogen compounds of molybdenum with great facility by treating an oxygen compound of molybdenum with nitrogen in the presence of a reducing gas, the process being carried out at a temperature under 800°C. (2 claims.)

26644/11. A. RICHARDS, London. **Recovery of Tin from Ores.** 28 November, 1911.

Tin is recovered from ores, tailings, slag, and other tin bearing material by converting the tin into volatile tin compounds. According to this invention, the tin bearing substance is mixed in a finely divided state with a small quantity of coal or other carbonaceous material or other suitable reducing agent, and with a small quantity of common salt, the mixture then being heated to a high temperature, preferably higher than cherry red. The tin on heating is volatilised as fume partly composed of chloride of tin, which is collected and treated in any well-known manner. (4 claims.)

27209/11. H. E. GREEN, Birmingham. **Sulphuric Acid.** 4 May, 1911.

For the concentration of sulphuric acid a plant of the cascade type is employed. According to this invention, the rectangular trays serving to separate the flue into upper and lower compartments, are mounted in a run so that at the commencement part they are disposed side by side and at a later part of the run are disposed singly one behind the other, the several parts of the run being disposed in close proximity one to the other in such manner that the direction of flow of liquid in each is reversed and so as to produce a compact, self-contained plant. (4 claims, 4 Figs.)

THE
CHEMICAL WORLD
A MONTHLY JOURNAL
OF
CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY W. P. DREAPER, F.I.C.

"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

VOL. I. No. 7. JULY, 1912. [ANNUAL SUBSCRIPTION 6s. Post Free. ,, ,, Abroad 8s. ,,] 6d. net.

BRITISH SCIENCE GUILD.

THE sixth annual meeting of the Science Guild has been held, and the president has announced that the total membership is about 900. As pointed out by our contemporary, *Nature*, this must, in ways, be regarded as a disappointing figure, and hardly normal for an institution which, necessarily aims at the enrolment of all those interested in the development of science in this country.

It may be, that the methods of the Guild have been too academic, and have not appealed to the general public. Before it can fully perform its functions, it must clearly have a thousand members where to-day it has ten. From its importance to the country, it should compare in prestige with the Navy League in Germany, which has a membership of over a million.

As the Guild can hardly hope to exercise a general influence in this country with so small a membership, it behoves all those interested in its welfare to extend its sphere of influence in every possible way.

The simple expedient of enrolling all members of the Scientific Societies of this country and the Colonies, as honorary members, would at once give it a membership of, say, 25,000 to 40,000. Notices of such, and of other matters might even be distributed by arrangement in the journals themselves. It would rest with the executive of the Guild to transform these nominal members into active units, and obtain their financial and general support in the further extension of its work and influence, and in time increase its present revenue of £113 to, say, £10,000. The different Scientific Societies might well be represented on its Council by nominated members.

The office number of the Guild should certainly be found in the telephone book. It must necessarily impress the public with its activity and the business-like nature of its affairs in every possible way. The idea prevailing in the past that a follower of science was in essence a visionary, should be finally brought to earth by this Guild. In this matter alone, it might serve a very useful purpose.

As a kind of Scientific Vigilance Committee, the Guild has pronounced possibilities. In many ways it could undoubtedly make itself extremely useful. We hold the opinion that University representation, if it is to continue, must sooner or later run on non-party lines. The Science Guild might possibly use its influence in this direction. It might also more definitely organise those members of the House of Commons who are directly interested in Science into a committee which might even in time be pledged to vote on non-party lines in cases where its deliberations and knowledge rendered this advisable in the common interest. It should have an active parliamentary committee.

The Guild could then speak from the floor of the House, and would definitely challenge public support and consideration. We do not think that this could satisfactorily replace an actual Science Party in the House of Commons; but it might well lead up to it, and prepare the way for more definite representation.

However influential its 900 members may be, and this is beyond dispute, they cannot in themselves constitute a great National League of Progress; the Guild must have a large following, and a considerable membership, in order that it may play a part in moulding modern thought. Under present conditions it might be argued that either the country is indifferent to Science, or else cares little for the Science Guild. We do not believe that either of these conclusions is correct, and that with a brave and frank policy, and increasing activity, the Guild may profitably extend its influence in many new directions, and become one of the most powerful institutions in the country.

We have drawn attention to certain points but fully realise the extraordinary difficulty in obtaining help for any movement of such a nature in this country. This is in itself a reason for greatest activity among the few who represent the Executive of this Guild.

Higher Education in Germany.

The Science Guild report draws attention to some interesting details given by Professor R. Tonibo, junr. In 1910-11, 54,822 students were enrolled for the winter session in the Universities. During the past five years the increase amounts to 12,432 students. Berlin, Münich, and Leipsig enrolled 39% of the total students. There are 9,686 students at the former University.

The total students in this country are 22,187, of whom only 8,174 are full-time students, and 1,710 in Wales. The total number of degree students is 4,400. Thirty-five technical institutions were recognised in this country giving advanced instruction in Science. The total number of students is 2,946, of whom 190 were in 1909-10 under sixteen years of age.

After making full allowance for population there are more than twice the number of students in the Hochschulen in Germany as in the corresponding institutions in Great Britain and Ireland.

The President of the Board of Education last year stated in the House of Commons that it was in the field of the high technological forces that we have most lee-way to make up. "When we make comparison of the number of students at German and English Universities," said he, "it is all to the advantage of Germany and not to our credit. In the eleven modern Universities of England at the present time full-time students number 9,600, and if you add 7,000 at Oxford and Cambridge of under- and post-graduates, you have a total for England and Wales of 16,600 students. It sounds like a large number; but when you remember that Germany has 63,000 students in similar institutions, we may well say we have a long journey before us."

The Science Guild's report expresses the opinion that "From the point of view of higher technical education it must be confessed that little progress has been made in this country." We think, however, that in this survey, the marked improvement in the colleges themselves has not been taken into account. This has been of a substantial nature, particularly at such centres as Cambridge on the one hand, or say, the City and Guilds Central Institution on the other.

Substitution.

The dictum "set a chemist to catch a chemist" recently put forward by a learned and distinguished member of the Bench, at one time known as a most successful leader in Patent cases, in its essence, expresses to-day's attitude towards a certain phase of industry.

The recent statement that the German jewellery trade has petitioned the Government to protect the public against the sale of "synthetic" stones, the manufacture of which was recently described in these columns, represents a case in point.

The chemist has directly aided in the cheapening of natural products. He has equally helped in the attack on fraudulent adulteration; often, as in the case of Dr. Wiley in America, fighting against almost overwhelming odds.

It is sometimes a matter of doubt, where actual adulteration comes in, and legitimate addition ends. This point, for example, is not yet definitely settled, so far as the Silk Industry is concerned. It is now known, however, that so-called artificial silk cannot be sold with impunity as the real article. Two recent decisions obtained by the Board of Trade at the instance of the Silk Association have generally settled this point. In one case it was even claimed by the defendants that it was almost impossible for them to purchase the real article (braid) from the wholesale houses, as it was no longer made.

The weighting of silk up to several hundreds per cent. has been practised for years, and the articles sold are labelled silk,—"pure silk" sometimes, to show that it is not a mixture of silk with cotton, or wool.

As is well-known, this fibre will take up large quantities of tin salts without appreciable damage to its lustre. In some cases weighting has been carried to extraordinary lengths.

The President of the Silk Association has recently asked the pertinent question,—Is such a product silk? There is no doubt that the weighted product has decreased in wearing properties, and that after exposure to the action of light it may sometimes become quite rotten. In extreme cases, it has been known to powder up!

In a possibly equivalent case of coffee, and mixtures of coffee and chicory, the nature of the article sold has to be declared. The matter is not so simple a question in the case of silk, as in some cases certain additions, which might be regarded as weighting, are added to get certain effects, which could hardly be obtained without them.

That the indiscriminate weighting of ordinary silk goods is not regarded as satisfactory, is seen in the fact, that foreign manufacturers have, in the interests of the trade, voluntarily agreed not to "weight" beyond a certain amount.

The question is an interesting one, when regarded from the point of view of what may possibly occur in other directions. In this case it is not the deliberate substitution of one fibre for another, as in the case of the linen prosecutions. The silk is there, if only to the extent of 30 %. The question probably resolves itself primarily into one of *substitution*.

It may sometimes happen that a treated or manufactured product has certain advantages. No one would think of prohibiting the use of mercerised cotton or artificial silk as products of commerce, or calling them adulterated cotton. The point at issue is fairly obvious. The value of such materials must be gauged on a money basis. If silk is valued at 16*s.* per lb., artificial silk at 6*s.* per lb., or tin salts at 6*d.* is hardly its equivalent. An artificial ruby which may be identical in chemical position with a real one, is an unsatisfactory product to the purchaser when sold at the price of the latter. An entirely different question, however, is the prohibition of the artificial products. It is too late to act in any such way in the case of artificial silk, and probably equally difficult to exclude artificial gems, as these have been on the market for a considerable time.

THE ESTIMATION OF POTASSIUM, ESPECIALLY IN FERTILISERS, SOIL EXTRACTS AND PLANT ASHES.

By WILLIAM A. DAVIS, B.Sc., A.C.G.I.

IT is still no uncommon occurrence to find the results returned for potassium by different analysts, even by those with special experience in this field, differing by very large amounts, in cases where there can be no possibility that the difference is due to sampling. In one case recently that came within the writer's experience, the results returned by two well-known London analysts differed by as much as 3 per cent. on a sample of 90% sulphate of potash. The writer, therefore, has subjected the present methods of analysis to an experimental investigation. The details will be published elsewhere, but the main results can here be briefly stated.

Considerable differences exist in practice as to the concentration of the alcohol used in taking up the syrupy mixture of sodium and potassium platinichlorides in order to separate the former, which is the more soluble. Many chemists adopt 80% alcohol, as recommended by Fresenius (*Zeit. Anal. Chem.*, 1877, *16*, 63), but others follow Precht (*Zeit. Anal. Chem.*, 1879, 509) in considering that absolute or high-percentage alcohol is preferable. This is the practice of the Stassfurt chemists, and Tietjens, in his article on Potash Salts in Lunge's *Chem. Tech. Untersuchungsmethoden*, bases this view largely on the fact that potassium platinichloride is less soluble in absolute alcohol (1 in 40,000) than in 80% alcohol. He considers the fact that more correct results are obtained by many chemists using 80% alcohol to be due to a "compensation of errors." In an important paper in 1906, Morozewicz (*Bull. Acad. Cracovie*, 1906, 796) contended that if absolute alcohol is used, not only are high results usually obtained, especially when sodium salts are present, but that three or four times more platinum chloride is necessary to keep the whole of the sodium in the form of Na_2PtCl_6 than when 80% alcohol is used.

The writer has fully confirmed Morozewicz' statements. Using a mixture of 0·1 grm. KCl + 0·1 grm. NaCl and more than sufficient platinum chloride to convert both the chlorides to platinichlorides, very high results were obtained (*e.g.*, 122·5% and 119·3% of the actual) for the K_2O present, when 95% alcohol was used for extraction and washing (105—110 cc. of alcohol being used in all). On washing *once* with 50 cc. of 80% alcohol on the other hand, the results became correct (99·4 – 100·4%); it was found that sodium chloride was dissolved by 80% alcohol out of the precipitate obtained with 95% alcohol, and could be recovered from it. But the platinum method, even using 80% alcohol, is always subject to the error that every successive 50 cc. of alcohol used in washing dissolves about 2 mgrm. of K_2PtCl_6. In the case of small precipitates, such as are dealt with frequently in the case of soil extracts, this relatively large amount may cause very serious error. There is always, too, the difficulty of recognising when the precipitate is just sufficiently washed; every additional washing lowers the result considerably.

Such error could of course be eliminated by using 80% alcohol previously saturated with potassium platinichloride for the washing.

Another grave source of error is found in analysing potash materials containing sulphates; in such case the sulphate has to be turned into chloride by treatment with barium chloride. In the Stassfurt method the precipitation has to be carried out very exactly, as a slight excess of either sulphate or barium chloride is very prejudicial. High results are easily obtained unless great care is used.

In Germany, the perchloric acid method has almost superseded the older platinum method (Precht, 7th *Intl. Congress App. Chem.*, 1909, Section I., p. 146), not only on the ground of economy (which at the present time, with platinum at £13 per oz., is a matter of great consideration), but in view of greater simplicity of working, and as being less liable to error, especially in dealing with sulphates. The writer has tested this method very thoroughly by using pure potassium salts either alone or in presence of other salts. It was found that even with small quantities of potassium very exact results were obtained; and that in such cases there is no necessity to convert the sulphate present into chloride by prior treatment with barium chloride. Thus a mixture of pure potassium chloride and sulphate containing 0·0307 grm. K_2O gave with the perchlorate method in successive results (1) 0·0305, (2) 0·0312, (3) 0·0305, (4) 0·0306, (5) 0·0307 grm. K_2O. Using 0·10 grm. of pure K_2SO_4 (representing 0·0541 K_2O), without any treatment by barium chloride, results (1) 0·0536, (2) 0·0536 grm. K_2O were obtained. Using 0·10 grm. of pure KCl, mixed with double this quantity of sodium chloride, sodium phosphate or calcium chloride, quite correct results were obtained, the added salts not interfering in the least. The same is true of barium chloride, which can be present in considerable proportion without causing trouble. Only in the case of large amounts of magnesium salts was difficulty encountered, when high results were obtained, unless the magnesium was previously removed.

* *

The perchlorate method has been applied by the writer with advantage to the analysis of soil extracts, plant ashes, and ashes obtained on evaporating the crude liquors of the manufacture of organic acids. The procedure is briefly as follows :—The solution of chlorides, containing iron, aluminium, phosphates, etc., is evaporated to dryness as in Neubauer's method (*Landw. Vers. Stat.*, 1906, *63*, 141) and ignited at a dull red heat. When magnesium salts are present, as is usual, after all hydrochloric acid is removed, 0·5 to 1·0 grm. of barium hydroxide is added. After ignition, the residue is extracted with boiling water, filtered into a glass dish, 2·5 to 5 cc. of 20% perchloric acid solution (sp. gr. 1·125) added, and the colourless solution evaporated nearly to dryness, until copious fumes of perchloric acid are evolved. The syrupy mass is then taken up with 20 cc. of 95% alcohol, and the residual potassium perchlorate transferred either to a Gooch crucible (with a layer of asbestos at least ⅛″ thick) or to a filter paper which has previously been dried and weighed in a stoppered weighing bottle. It is washed with 30 to 70 cc. of 95% alcohol, to which 0·2% perchloric acid has been added, and then with 95% alcohol alone, until the washings are free from acid, as tested by sensitive litmus paper. The precipitate is dried to constant weight in a steam oven. 1 mgrm. $KClO_4 = 0{\cdot}340$ mgrm. K_2O.

In view of the grave errors to which the platinum method is subject, there seems no good reason for longer retaining it, in view of the fact that a more accurate and simple method of analysis exists in the perchloric method. Its abandonment is, moreover, desirable not only on grounds of economy, but as eliminating the vexed question as to the value that shall be chosen for the atomic weight of platinum in potash analyses (see Precht, *Intl. Congress App. Chem.*, 1909, Section I.). In the perchloric acid method the ratios involved are the simple molecular rations such as $\frac{KClO}{KCl}$, or $\frac{2KClO_4}{K_2O}$, in which the atomic weights used have all been accurately fixed.

RECENT PROGRESS IN THE SYNTHESIS OF NATURAL ALKALOIDS.

By ARTHUR CLAYTON, D.Sc. (LOND.), A.R.C.S.

MORE than twenty years have elapsed since Ladenburg elaborated his process for evolving coniine from acetic acid, and so effected the first synthesis of a natural alkaloid. This brilliant precedent paved the way for numerous attempts which have since been made to synthesise other alkaloids, and the artificial production of such important substances as atropine, nicotine, and adrenaline shows that these efforts have already met with considerable success. The difficulties attending the synthesis of natural alkaloids, however, are very great, chiefly owing to the elaborate structure generally possessed by these compounds, and the consequent difficulty of determining their chemical constitution. It is not surprising, therefore, that the great majority of the natural alkaloids have not yet been prepared in the laboratory, and that many of the most important are still of unknown constitution. Nevertheless, the assiduity with which the problems have been attacked has in many cases triumphed over the difficulties inseparable from the investigation, and ten years ago the list of synthesised natural alkaloids included piperine, coniine, hyoscyamine, atropamine, *r*-cocaine, tropacocaine, arecoline and arecaidine.

During the last decade, this list has been enriched by the addition of papaverine, laudanosine, narcotine gnoscopine, nicotine, berberine and adrenaline.

The preparation of the first four of these more recently synthesised alkaloids gives evidence of the energy and success with which the investigation of the opium alkaloids has been conducted. The synthesis of papaverine and laudanosine is due to Pyman,[1] who obtained the former of these compounds by the interaction of aminoacetoveratrone and homoveratroyl chloride, followed by reduction and elimination of water. Laudanosine was obtained from papaverine by reduction and methylation ; this preparation is of special interest as it constitutes the first example of the artificial production of an opium alkaloid. Salway has completed the synthesis of narcotine[2] by the production of cotarnine from myristicin, whilst gnoscopine has been shown to be the racemic form of narcotine.

Nicotine, notable as the only alkaloid occurring in the tobacco plant, was synthesised by Pictet and Rotschy[3] from 3-aminopyridine. This interesting synthesis involved numerous reactions, and forms an inspiriting example of the manner in which experimental difficulties attending such syntheses may be surmounted by assiduous effort and clear ideas of chemical constitution ; moreover, it led incidentally to the isolation of the dextro-rotary base which is optically antipodal to the tobacco alkaloid, and which does not appear to have any origin in living processes.

Berberine, the synthesis of which was foreshadowed by the preparation of oxyberberine, was obtained artificially a few months ago by Pictet and Gams.[4] Homopiperonylamine and homoveratroyl chloride were condensed and the product heated with phosphoric oxide. The resulting compound was reduced, and a methylene group introduced by condensation with methylal. These operations gave rise to tetrahydroberberine, from which berberine was obtained by oxidation.

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[1] *Trans. Chem. Soc.*, 1909, *95*, 1610.

[2] *Trans. Chem. Soc.*, 1910, *97*, 1209.

[3] *Berichte*, 1904, *37*. 1225.

[4] *Berichte*, 1911, *44*, 4149.

The synthesis of adrenaline is remarkable, both for its commercial value, and as an example of the artificial production of an alkaloid hitherto only obtainable from animal sources. This alkaloid is largely used as a hæmostatic agent, and its artificial preparation on the commercial scale is of undoubted general utility. The substance was synthesised by Stolz,[5] who treated catechol with chloracetyl chloride, and condensed the resulting chloracetylcatechol with methylamine. These operations yielded monomethylaminoacetylcatechol, which, on reduction, is converted into adrenaline.

A survey of the foregoing syntheses shows that steady progress is being made in the artificial preparation of natural alkaloids. These syntheses, however, do not by any means represent the only advances in this direction, for further researches have shed much light on the constitution of other alkaloids. The constitutions of strychnine and brucine, for example, are becoming better understood, and it can scarcely be doubted that with the ever increasing resources of the synthetic chemist, the problem of the synthesis of these and allied alkaloids will soon be solved.

The cinchona alkaloids also form a subject which has received a great deal of attention. Rabe has completed the synthesis of the bridged bicyclic system which characterises these compounds, thus laying the foundation for the synthesis of cinchonine and quinine.

The study of the synthesis of alkaloids, apart from the immediate object in view, is of great value in the proper comprehension of those mysterious changes which are produced within the tissue of living organisms. Pictet has suggested the general idea that alkaloids are formed in plants by the breakdown of complex substances, followed by the condensation of the simpler products so obtained. The same chemist has also put forward the interesting hypothesis that the alkaloids of the isoquinoline group owe their origin to some such process as that followed in the interaction of formaldehyde and β-phenylethylamine. This reaction takes place very readily, and Pictet's hypothesis is undoubtedly more in accordance with experimental facts than any other yet proposed.

The processes by which alkaloids are formed in plants are full of interest, and by the study of these processes, suggestions may be obtained for further syntheses of natural alkaloids. Specially significant in this connection is the well-known fact that pyridones, tautomeric forms of hydroxypyridines, are obtainable from the corresponding pyrones by the action of ammonia, and when it is recalled that several pyrone derivatives are formed in plants, *e.g.*, meconic and chelidonic acids, it is readily conceivable how alkaloidal products might arise from the union of such compounds with the substituted ammonias constituting the building materials of proteid molecules.

Finally, it may be said that it is almost impossible to over estimate the importance of the alkaloids to mankind. The use of quinine, for example, has swayed the destinies of every section of the community, and many other alkaloids have received application in the practice of medical science. Progress in the study of the alkaloids, therefore, must be regarded as progress of the highest order, and research performed in this direction is pregnant with the greatest possibilities for the welfare of humanity.

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[5] *Berichte*, 104, *37*, 4149.

MAGNETIC SUSCEPTIBILITY.

By A. W. STEWART, D.Sc.

WITHIN the last two decades the relations between the physical properties and chemical constitutions of compounds have been investigated more closely than at any previous time, and, though the results obtained have not always been in harmony with those deduced from purely chemical experiments, yet no one can doubt that these studies have rendered invaluable aid in many disputed cases. The polarimeter, the refractometer, the spectroscope and other instruments have been pressed into the service of chemistry and have been applied to the study of chemical constitution. It is clear that these physical methods have one great advantage and a corresponding disadvantage when applied in this way. The advantage lies in the fact that they enable us to make a guess at the constitution of a substance in the pure state when it is not affected by the presence of any other reagent, which is, of course, impossible with most chemical methods. The disadvantage is found when the purely physical method gives results at variance with those obtained by chemical means. Our chemical formulæ are based on the assumption that they represent the chemical behaviour of substances rather than their actual constitution, whereas the physical methods give results based upon constitution and not upon the mode of reaction of the compound examined. Thus in certain cases we are faced by a divergence in the results of the two methods which at the first glance is rather puzzling.

Physical properties may be roughly divided into three classes: colligative, additive and constitutive. Of these, the members of the first class depend merely upon the number of molecules present. In the second category are those in which we can arrive at the properties of the molecule by a summation of the properties of the various atoms contained in it. The third class is made up of those properties in which the preponderating factor is the mode of grouping of the atoms within the molecule.

From the point of view of the determination of chemical constitution, it is hard to estimate whether additive or constitutive properties are of most value; both have been of assistance to the chemist; but some properties which partake of the nature of both additive and constitutive ones have rendered the greatest service. Of these, refractive index and magnetic rotary power have been of the widest application. In recent years another physical property, magnetic susceptibility, has been studied in some detail, and it appears likely to rank with the better known ones in the future.

Faraday was the first to show that in addition to elements like iron and nickel there were other substances which could be affected by a magnetic field. For example, if we suspend a bar of bismuth between the poles of an electro-magnet we shall find that, instead of lying between the poles as an iron bar would do, the bismuth bar will take up a position at right angles to that assumed by the iron rod. Thus we have paramagnetic and diamagnetic elements. Wiedemann[1] later studied the question of the magnetic properties of iron in its salts, and showed that when iron entered into a complex ion, like the ferrocyanide one, its magnetic properties were decreased. From this it became clear that the constitution of the compound could exercise some influence upon the magnetic properties of its components. This line of work has been taken up recently by Pascal; and we may here give a brief description of the apparatus used and the results obtained by him in his investigations.

In its essentials, the apparatus[2] consists of two parts: an electro-magnet and a tube, in which the rise and fall of a liquid can be measured and varied at will. The tube (which is filled with the liquid to be examined) is placed in the field of a powerful electro-magnet and, after the magnet has been closed, the level of the meniscus is raised in the tube until it reaches a fixed point in the field. This is done to obviate any irregularity due to the variation of the intensity of the field at different points. Having the meniscus thus fixed, the circuit is broken; the magnet is demagnetised, and consequently the magnetic influence is removed from the liquid, which falls slightly in the tube. The extent of the fall is read off; and this gives us a measure of the magnetic influence upon the liquid. In another apparatus devised by the same investigator, the tube containing the substance under examination is accurately counterpoised and the effect of the magnetic field is estimated by direct weighing during the passage of the current. Water is taken as the standard, just as in investigations on magnetic rotatory power.

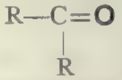
In this earlier work Pascal[3] confined himself to compounds of iron; and he was able to show that when, in solution, the metallic ion of a salt passes into a complex ion the metal loses, in the new compound, a part or the whole of those magnetic properties which it possesses in its normal salts. This attenuation of magnetic properties may even be carried to the point of inversion. Further, there is a parallel variation in the magnetic and analytical characters of these ion derivatives: for in cases where the iron is readily detected by ordinary reagents (such as sodium hydrate or ammonium thiocyanate) the molecular magnetic susceptibility was high; whereas it was low in cases such as sodium nitroprusside, which does not give the ordinary analytical reactions of iron.

Pascal next[4] turned to organic substances. In this field he had been preceded by Henrichsen,[5] who had shown that in certain compounds of the aliphatic series magnetic susceptibility was an additive property. Pascal proved that isomers, such as methyl benzoate and phenyl acetate, had the same degree of susceptibility, which demonstrates that in these cases the magnetic property is an additive one, pure and simple: and he determined the constants of the various elementary atoms which enter into the commoner organic substances. In the course of his work he found that (just as is the case with refractivity or magnetic rotation) the presence of double bonds between atoms in the molecule had a special influence as their presence markedly diminished the molecule's diamagnetic properties. The accumulation of halogen atoms in the molecule appeared also to have some influence, for when several halogen atoms were attached to one carbon atom their diamagnetic capacity appeared to be masked to some extent. From this it is clear that magnetic susceptibility resembles refractivity in being largely additive, but also to some extent dependent upon constitutional factors.

Further investigation[6] proved that this constitutional factor was by no means negligible. For example, an oxygen atom linked to two other atoms is markedly diamagnetic and has an atomic susceptibility of -50×10^{-7}; if it be doubly linked to carbon, as in the ketones and aldehydes, it is paramagnetic with a susceptibility of $+20 \times 10^{-7}$; but if we attach a second, singly-linked oxygen atom to the carbon atom, as in the carboxyl radicle, the doubly linked oxygen atom becomes diamagnetic with a susceptibility of -35×10^{-7}.

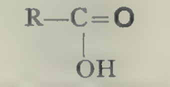
$R{-}O{-}R$

Diamagnetic Oxygen.



$$\begin{array}{l} R{-}C{=}O \\ \quad\;| \\ \quad\; R \end{array}$$

Paramagnetic Oxygen.



$$\begin{array}{l} R{-}C{=}O \\ \quad\;| \\ \quad\; OH \end{array}$$

Diamagnetic Oxygen.

Again, if a compound contains a tertiary carbon atom, its molecular susceptibility is increased by -10×10^{-7}; while a quaternary carbon atom causes a still greater increase, -15×10^{-7}.

From these examples it will be seen that in magnetic susceptibility we have a new weapon with which we can attack the problem of molecular constitution.

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[1] Wiedemann, *Pogg. Ann.*, *127*, 1; *135*, 177.
[2] Pascal, *Ann. chim. physique.* (8) *16*, 535.
[3] Pascal, *Ann. chim. physique.* (8) *16*, 531.
[4] Pascal, *Comptes rendus*, *149*, 342.
[5] Henrichsen, *Wiedemann Ann.*, *34*, 180.
[6] Pascal, *Comptes rendus*, *149*, 509.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

SCIENTIFIC METHOD IN CELLULOSE INVESTIGATION.

By C. F. CROSS.

IN a recent article, Vol. I., p. 84, it was suggested that the term "cellulose" is conceived and applied very variably in scientific investigations and writings, and the need of precise definition was emphasised. The definition required is rather that of quantitative results than the mere selection of appropriate words or terms in which to fix the generally accepted data.

The article sounded rather an apologetic note, as it was felt that the matter was obvious and embodied conclusions generally accepted. But our attention has since been called to a series of articles, just completed, in the *Zeits. Farben. Ind.*, 1911-12, on the "Estimation of Cellulose in Woods and Textile Fibres," in which the authors, J. König and F. Hühn, seek to maintain a position so far removed from what may be regarded as generally accepted—if not entirely obvious—that we are justified in returning to the subject without even an implied apology.

It evidently *is* necessary to insist upon fundamental points and clear definitions in this region, as we shall endeavour to show by taking the work of these authors as a text. We must premise one or two preliminary points.

It is clear that methods of estimating cellulose and the critical evaluation of such methods, briefly summarise our fundamental knowledge.

Now, all our investigations issue in two main conclusions in respect of cellulose. Cellulose is only known to us as a residue of processes of "purification" of fibres or cellular raw materials: and as these processes are not without action on the cellulose, the residue is of necessity a variable, varying with the process and the conditions and intensity of action.

It is, therefore, incorrect to speak of the estimation of cellulose as we should of, say, silica in a complex silicate. The analyst does not concern himself with the phases of silica in the process of its separation from a mixture: it is sufficient that it is isolated and finally ignited to be weighed as SiO_2.

In the isolation of cellulose we proceed by way of systematic exhaustion: (a) by neutral solvents, *e.g.*, ether, alcohol, water; (b) by simple hydrolytic agents, mainly alkaline, treatments of this group being carefully regulated to produce the minimum of change in the cellulose.

Thus exhausted, the residue is a possible mixture of cellulose, ligno-cellulose and cuto-celluloses. In the majority of cases the latter are present in insignificant proportions. The major problem in a process of cellulose estimation is the elimination of lignone constituents, and it is this problem which has been the main subject of the investigations of König and Hühn.

These investigations have covered the range of processes identified with the names of Henneberg (Crude fibre, "Rohfaser"), König, H. Müller, Cross and Bevan, Schulze, Tollens, and others. A similar comparative study has been recently made by M. Renker (*Inaug. Diss.*, 1909, Berlin), with the result of confirming the general adoption of the process of chlorination. This investigation and its conclusions have been favourably received by specialists and technologists, and also endorsed by the International Commission, and it would be considered gratuitous to re-open the subject.

But König and Hühn are not influenced by this antecedent position. They consider that the chlorination method does *not* estimate, *i.e.*, isolate cellulose, but a complex of "true cellulose," hemi-hexosanes and pentosanes.

Their conclusion is evolved from the comparative study of the "König" process, the basis of which is a digestion of the cellulose material with a special acid reagent, glycerine-sulphuric acid, *i.e.*, a solution of 20 grms. H_2SO_4 in 1,000 c.c. glycerine, the digestion being carried out at 137° C. Chemists will not need to be reminded that the typical cellulose cotton is profoundly attacked, and constitutionally modified under this treatment. The authors record that the product from cotton is a friable powder, representing 88% of the weight of a cellulose isolated by the chlorine method. But it is a "true cellulose" freed from the "hemi hexosanes" of the reputed "normal cellulose." And "plain" chemists will be interested to know how this unexpected judgment is justified.

Since all criteria based upon hitherto accepted principles must have failed, the authors have devised a further little scheme of verification of their own. Dissolving the product in the $ZnCl_2HCl$ solvent, they observe the specific rotation which slowly develops to a maximum (2—3 days) as a result of hydrolysis, to again diminish, apparently as the result of inverse processes of condensation. Cellulose "purified" by the glycerine-sulphuric acid method is found to give the highest maxima, specimens isolated by the chlorination process give lower maxima, whence it is concluded that the König product of decomposition is the "true cellulose," and the accepted standards of normal cellulose are by comparison heterogeneous mixtures.

As a result of further critical discussion of this group of methods, the authors select, as next in order of distinction, a recently published method of Tollens and Dmochowski (*J. F. Landw.*, *58*, 1, 1910), which consists in first obtaining the "rohfaser" residue of successive hydrolyses, acid and alkaline, and digesting this residue with strong nitric acid to eliminate unsaturated and oxidisable groups. The finally purified residue is weighed and the result is then subjected to a simple treatment of rehabilitation, being multiplied by the factor 1·1, the "corrected" figures showing quite respectable approximations to the yields of cellulose by standard methods.

It is really difficult to criticise these conclusions and proposals. One can only take the distinguished names of the chemists who father them as a guarantee that they are based on unexceptionable laboratory methods, and as studies of degradations of cellulose they have undoubted value.

In the preceding article in this journal (*loc. cit.*) the author dealt with the question of the "normal cellulose" and its definition. That definition involves a threefold standard of convergent verifications—resistance to hydrolysis, resistance to oxidation and maintenance of structural integrity as expressed in terms of breaking strain and elasticity.

We may now, with advantage, add a complementary standard of criticism upon which to meet and dispose of the suggestions of the authors whose work has been thus briefly described.

"Cellulose," as a section of science, rests upon a tripod composed of the plant, that is the plant world: the factory, that is the manufacturing industries of which cellulose is the raw material; the laboratory, that is the pure chemical science of the subject.

The perception of these relations and the order of their interdependence may be a matter of intuition. It may be clear to the child *or* the philosopher, it certainly does not automatically rule, and adjust the perspective of the great "middle class," that is the class between these two more important sections of the family. If it did, we suggest, we could not be seriously asked to bring our estimations of cellulose into line with arbitrarily selected laboratory products of breakdown, undefined except by methods involving necessarily an almost unthinkable complexity of interactions.

Whatever we know of cellulose is conditioned by such stereoscopic view as we now obtain by observation in the directions of vision aforesaid. "Normal products" of the laboratory are normal when they further conform with the exigencies of manufacturing industry, and as industry in this case is only a development of economic botany or vegetable physiology, but on a lower plane, we have to compare our "industrial normal" with the "natural" normal products.

Such views are the working atmosphere of the school we claim to represent: we only become aware that these principles are not self-evident when we find ourselves in the presence of contributions such as those under discussion, written from an entirely divergent point of view and criticism.

Our opinion is that, as there is no question of difference as to experimental numbers, and the divergence is one of fundamental interpretation, there are psychological factors even of so impersonal an issue as "the normal cellulose," and the best method of estimating it.

In such a case, we appear to arrive at an *impasse* in which experimental numbers lose their significance, and it is, we think, therefore, opportune to formulate the general perspective of the methods thus attacked and leave the issue to our fellow-students.

It may, perhaps, be useful to younger students to put on record a condensed bibliography of the main line of development of the now established practice in the analysis of cellulosic raw materials, as follows:—

H. Müller, Pflanzenfaser, Leipzig, 1876. (Method of isolation of cellulose by Br. Aq.)

M. Vétillart. "Etudes sur les fibres végétales textiles," Paris, 1876. (Quantitative estimation by microscope.)

Cross and Bevan. "The Chemistry of Bast Fibres" (*Jour. Chem. Soc.*, *41*, 90, 1882.) (Method of isolation of cellulose by chlorination). Reports. Col. Ind. Exhibition, London, 1887. Article, "Miscellaneous Fibres." (Systematic analysis of vegetable raw materials.)

Dean and Tower. "Determination of Cellulose in Wood by the Chlorination Process." (*Jour. Amer. Chem. Soc. 29*, 1,119, 1907.) (Study of chlorination process in relation to more resistant lignocelluloses.)

M. Renker. "Uber Bestimmungs Methoden der Cellulose." Berlin, 1909. (Dissertation.) Comparative study of all known processes of estimating cellulose.

THE ACTION OF ACIDS ON CONCRETE.

By WALTER C. HANCOCK, B.A. (Cantab), F.I.C.

FROM time to time a number of articles have appeared in technical journals dealing with the action of water, containing salts in solution, upon the time of setting, hardening and permanence of cement and concrete. On account of the extensive use of Portland Cement in the construction of docks, piers and sea-walls, many of these contributions have naturally been devoted to the action of sea-water. Very few published references, however, exist, that deal with the action of acids on concrete, though the subject is of considerable importance in view of the wide application of cement in the construction of reservoirs, drains, etc. Instances have occurred in which defects, resulting in some cases in serious disintegration, have arisen in such constructions and could not be attributed either to inferior materials or to careless workmanship. Though the chemical reactions involved were often comparatively simple, a very searching investigation has sometimes been necessary in order to arrive at the true explanation of the failures and to trace the origin of the reacting substances, and the path by which they have found their way to the concrete. For example, some of the failures have been shown to be due, not to substances actually in solution or suspension in the liquids which were sought to be retained in reservoirs, or conveyed by pipes, but to the action of constituents of the soil in which the concrete was embedded. Without entering into minute details, a brief survey of some recorded results may perhaps be of interest.

Among the preponderating constituents of Portland cement, lime, silica and aluminium and ferric oxides, lime is obviously one of the first to consider in relation to the action of acids, and owing to its wide distribution both in the atmosphere and in water, carbonic acid naturally suggests itself as one of the first acids to consider. In the case of hardened cement, any calcium hydroxide on the surface is converted by the carbon dioxide of the atmosphere into calcium carbonate. Calcium hydroxide is only very slightly soluble in pure water, but as is well known the carbonate dissolves somewhat easily in water containing carbonic acid in solution, owing to the formation of the bicarbonate. Further, in the presence of water, calcium silicate and aluminate in the concrete may be hydrolysed to calcium hydroxide, the amount of which available for the above reaction being thus increased, and colloidal silicic acid and alumina. In this way the removal of lime from the cement leaves a more or less gelatinous coating of silicic acid and aluminium and ferric hydroxides on the surface of the remaining concrete, which is regarded by many as very resistant and as providing an effective protection against the further solvent action of water containing carbon dioxide in solution. The formation of this protective coating is also said to be favoured by the presence of organic substances, and should not be disturbed.

The action of the strong mineral acids on concrete may be regarded, in a broad sense, as falling into two classes, according to whether the products formed by their action on constituents of the cement are soluble or not. Hydrochloric and nitric acids of course with the lime form soluble salts, and it must be borne in mind in this connection that the concrete is not merely impoverished by the removal of these soluble substances, but is also weakened by the actual physical disintegration involved in their removal. Sulphuric, sulphurous, which is readily oxidised to sulphuric, and hydrofluoric acids on the other hand form insoluble calcium compounds, and with regard to these the view, supported by Rohland, has generally been taken that they afford a protective coating to the cement and exclude further action by the acids. At the same time, it has been recognised that calcium sulphate may have a serious disintegrating effect on account of the mechanical force it exerts on combining with water. This expansive force is also probably increased by the formation of a double salt of calcium and aluminium, with as many as 30 molecules of water of hydration. In one or two cases of failure of concrete drains some ingenuity has been required to trace the source of the sulphur and its subsequent conversion into sulphuric acid. A main drain, laid at Osnabrück in 1902, was found to be defective after about two years. The concrete became friable, and white crystals, which proved to be calcium sulphate, appeared. The drain was laid in marshy ground in which considerable quantities of pyrites were present. So long as the pyrites is surrounded by sub-soil water it is harmless, but when the level of the water sinks from time to time the soil becomes aerated and the pyrites is converted into ferrous sulphate, which is easily removed in solution, and sulphuric acid. In this particular case, the fluctuations of level of the water were considerable, and by the excess of pressure developed, sulphuric acid was forced into the drain, so that the interior was also attacked, and the initial layer of calcium sulphate, deposited along with organic matter, does not appear to have had any useful protective effect.

(*To be continued.*)

THE "EXCESS LIME" METHOD FOR STERILISING DRINKING WATERS.

By S. RIDEAL, D.Sc., F.I.C.

COMPLAINT has often been made with justice that our nation, although admittedly pioneers in many departments of scientific industry, and particularly in that of sanitation, has for a long time lagged behind other peoples in carrying the results of the researches and discoveries of private individuals into general application for public benefit, and has allowed other nations to snatch from us the fruits of our work. It cannot be doubted that the chief reason is our former neglect of scientific education, leaving such an ignorance and indifference that any government proposing expenditure for science research often met with vigorous opposition. Therefore the subject was surrounded with bewildering patents aiming at private profit, to at any rate recoup the inventors for their own expenditure and labour.

The reproach can no longer be urged in one direction, that of the Metropolitan Water Board, which has for some years been in possession of a State Research Laboratory similiar to those in other countries, with an able Director, Dr. A. C. Houston, and a staff of assistants, issuing a series of valuable reports on water purification. A great part of the work of an investigator is to clear the ground of a number of erroneous or rash previous assertions, and this Dr. Houston has done tenderly and critically.

Confirming the fact noticed by earlier observers that pathogenic organisms commonly disappeared in waters when kept, Dr. Houston recommended storage as a method of rendering London Thames water safe, but the storage must not be less than two weeks, and might with advantage be one or two months. This, of course, involved the construction of enormous and costly reservoirs for London's water supply, and in addition the Third Research Report on Storage desired that the raw river water should be first passed through a small settling basin to remove the rough impurities before entering the storage reservoirs proper. But in the Seventh Report of December, 1911, the disquieting remark is made (p. 36) that "despite the remarkable improvement effected by storage even when much of the river water passed into the storage reservoirs is far from satisfactory, it seems unwise to trade too greatly on the circumstance if any practicable remedy, even of a partial kind, is available." There is also an interesting discussion and investigation of the use of coagulants and a hint (p. 37) of "additional processes of purification."

One of these methods was foreshadowed in a footnote to p. 73 of the Seventh report, where Dr. Houston says "I have found that quicklime (about 75% CaO) added to raw Thames water in the proportion of one part of quicklime to 5,000 parts of water kills *B. coli* in 5 to 24 hours," and the idea of carrying it out in practice was hastened by the failure to acquire parliamentary sanction to the *complete* scheme for storage (New Works Bill, 1911) on account of the immense outlay and certain other inconveniences. In his Eighth Report of February, 1912, in which these circumstances are described, he records further experiments on "excess lime" as a steriliser for water, and summarises disadvantages and advantages with a strong balance in favour of the latter. "Its complete fulfilment would raise the purity of the Metroplitan Water Supply to a pitch of perfection never before attained . . . by any waterworks authority in the world, dealing with sources comparable with those of London." His summary at this stage is (p. 15): "15 lbs. of quicklime, costing 1½d., would be added to 7,500 gallons of raw unstored Thames water. This would kill within 24 hours the *B. coli*, and inferentially, but certainly, the microbes also of epidemic water-borne disease, *e.g.*, the typhoid bacillus. The water would also be improved considerably as judged by chemical and physical standards. The excess of free lime (about ·007 per cent.)[1] would then have to be neutralised with 2,500 gallons of *adequately* stored water, which, according to all my experiments, would not contain any of the microbes of epidemic water-borne disease. . . . Rapid filtration alone would then be required to remove the precipitate of inert carbonate of lime." According to the data given, the initial average hardness of 15° Clark is reduced in the final mixture to about 5·3, but of course the sulphates are left, so that there would appear to be no danger of the water being rendered lead solvent, like soft waters generally, though this point is not mentioned. It is stated (p. 17) that the L. C. C. in their sewage treatment use annually 25,000 tons of lime, costing 13s. 9d. per ton in 1910, and containing 95% of CaO, which is much cheaper and also of greater strength than the material used by Dr. Houston in his researches; nevertheless while admitting (p. 16) that "the disadvantages of the excess lime method grafted on to an existing water purification are many and serious," he says that the mere cost of lime would probably be about double that of the present sand filtration.

Dr. Houston's experimental colicide success with 1 part of quicklime added to 5,000 parts of water amounts to 20 parts of CaO per 100,000, or 14 grains per gallon, equal to 1·2 tons of this quicklime per million gallons. Obviously the proportion of free lime neutralised and rendered inert by the carbonic acid of the water would be variable from time to time, and the quantity required to give the effective bactericidal excess would have to be continuously tested, also the volume of stored or otherwise sterilised water required to neutralise the excess lime.

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[1] 4·9 grains per gallon of CaO, equal to a hardness of 8·8° Clark.

We must remark that the action of lime on bacteria is by no means a recent "discovery," neither is the "excess lime" idea. When Clark introduced his process in 1841 its object was only softening, and it was applied on a large scale at Canterbury about 1860, while at Southampton the water has been softened with lime since 1888. But it was soon found that there was a removal, and to a certain extent a killing or inhibiting of the organisms. At Cincinnati, Ohio, in 1899, lime water was applied to the river water in quantities to give an excess of about 3 or 4 grains per gallon of lime after settling. It produced a satisfactory quality as to the removal of bacteria and organic matter, and the product was re-carbonated to remove the caustic alkalinity due to excess of lime. At Winnipeg, Manitoba, cream of lime is added automatically, the water is than settled, passed through filter presses and afterwards re-carbonated by passage through it of CO_2 from burning coke. At Columbus, Ohio, a softening plant of 30 million gallons capacity was erected in 1906, for treating with lime the water supply from the Scioto river, and is stated to remove nearly all the bacteria. The caustic alkalinity is neutralised by sulphate of iron, with final mechanical filtration. This has the fault of leaving calcium sulphate. A similar plant for 40 million gallons is used at New Orleans for the Mississippi water. Fuller mentioned in 1906 the use of "raw water" sterilised with sulphate of iron for removing the residual caustic alkalinity (Proc. Amer. Waterworks Assoc., 1906, p. 126). Dr. Burlureaux of Paris is quoted as having shown that bacteria are actually destroyed in the softening with lime.

Prof. Percy Frankland published investigations on the effect of lime on micro-organisms in 1885 and 1886 (Proc. Roy. Soc., 1885; Proc. Inst. Civ. Eng., 1886), and stated that in the Colne Valley (Herts) Waterworks, where lime was used, the subsidence of the precipitated carbonate of lime was so rapid that the water after three hours was often ready for distribution, while he found that the average reduction of the organisms was from 322 per c.c. to 4, or 99 %. He also remarks ("Micro-organisms in Water," 1894, p. 191) that by excess of lime the most remarkable diminution in the bacterial contents of water may be effected, and that such treatment, carefully carried out, must therefore afford the most substantial obstacle to zymotic poisons reaching the consumer. Some of his experiments were made with London (Thames) water.

The fault in this respect of a mere softening with a minimum dose of lime is that the action is only a partial removal of the organisms and that only some of them are killed. It has long been known that when sedimented for some days the mechanically carried down or inhibited bacteria rise again and develop in immense numbers in even the upper layers, hence the reason of the "excess lime" method, which is found by Dr. Houston to effect sterilisation, and not a mere temporary removal.

Kruger (*Z.f.Hyg.*, 1889) confirmed the above-mentioned after-distribution and multiplication in a number of waters. In a typical instance he added slaked lime equivalent to 14 grains per gallon of CaO, by which the water was rendered strongly alkaline. The average number of organisms per c.c. was, in the unlimed water: 1st day, 5,142; 3rd day, 21,234; 23rd day, 15,714. In the limed water: 1st day, 662; 3rd day, 824; 23rd day, 1,580. In the first case the reduction in the longer time is probably due to the well-known effect of storage. In the treated water the multiplication has continued though the numbers are much less, therefore the excess lime, as Frankland remarks, has acted as a bactericide.

It is well known that water which has been treated with lime is slightly caustic and has a deficiency of carbonic acid; it is also apt to give "after troubles" in the shape of lime deposits in the pipes, pumps and conduits. Hazen observes that although precipitated calcium carbonate is comparatively soft, it rapidly destroys pumps used for lifting it. The process has been followed by a second stage of re-carbonation, but even then a flat taste and want of brilliancy has often been complained of in the treated product.

The precipitate is heavy and granular, and is largely removed by sedimentation, although filtration is necessary to complete the process. Iron and clay are incidentally removed, so that storm water can be used, instead of wasted. At the same time the difficulty of dealing with the heavy deposit must be remembered.

At Lawrence, Mass., it was found that sewage was almost completely sterilised by the application of "excess lime" (Report Mass. B. of Health, 1890, p. 747), and Fuller made a similar observation in regard to water at Cincinnati in 1899, where he obtained "extremely favourable" bacterial results, but had a difficulty in removing the excess lime.

Evidence of the effect of lime on sewage has an intensive value as regards the treatment of water, since in the former the bacteria are so much more numerous, and pathogenic ones are constantly present. The Rivers Pollution Commission of 1868 declared against the use of lime alone, on the ground that the liquid was not sterilised, and rendered alkaline and ammoniacal, and soon became fouler than before, and this opinion was supported by many prosecutions for nuisance where lime and sedimentation were used alone, although lime is employed effectively as an adjunct to other processes. When lime by itself has been used for sewage, the dose has been commonly one ton per million gallons or 15·7 grains per gallon. The bactericidal effect of excess lime on the other hand was proved by the Massachusetts Board of Health, it being only, as we know, a question of quantity.

From a sanitary standpoint there is no evidence that within ordinary limits the hardness of water has much, if any, influence on the health of the consumers. Public supplies have had to be softened when exceptionally hard, and hardened when plumbo-solvent, and both processes, owing to the necessary filtration, cause a great improvement in the quality of the water. A sterilising process after ordinary filtration is the only safe course. Dr. Houston's proposal of sterilising three-quarters of the raw water by lime, then mixing it with one-fourth of its volume sterilised by storage or *otherwise*, is ingenious as an attempted way out of the difficulty. But the one-fourth must, as he admits, have been rendered unimpeachably safe, and it is a question whether this should be done by ozone or chlorine. In a period of "bacterial peace" — that is, when no extraordinary epidemics were creating alarm—although on the other hand a constant quiet incidence of unhealth due to micro-organisms is always occurring, it is difficult to persuade a nation that spends so much in military protection to afford sufficient means for guarding against an equally dangerous invasion of germs of disease. Dr. Houston remarks that "considered solely from the point of view of the future safety and purity of the Metropolitan Water Supply, the outlook, in my opinion, at the beginning of 1912 is less satisfactory than it would have been if the Board's full proposals had received the sanction of Parliament."

THE SCIENTIFIC AND TECHNICAL DEPARTMENT OF THE IMPERIAL INSTITUTE.

By Thomas A. Henry, D.Sc. (Lond.), Superintendent of Laboratories, Imperial Institute.

The Imperial Institute was erected at South Kensington as the National Memorial of the jubilee of Queen Victoria, by whom it was opened in 1893.

Up to the end of 1902 the Institute was managed by a governing body, presided over by H.R.H. the Prince of Wales (afterwards King Edward VII.). In 1900 the building became the property of the Government, and certain parts of it were assigned for occupation by the University of London. In July, 1902, an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee. Five years later an arrangement was made with the Board of Trade, with the approval of the India Office, whereby the management of the Institute was transferred to the Colonial Office, subject to the responsibility of the Board of Trade under the Act of 1902, and a Committee of Management of three members was appointed, one nominated by each of the three Government departments chiefly concerned — the Colonial Office, the India Office, and the Board of Trade.

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Prof. Wyndham Dunstan, M.A., LL.D., F.R.S., Director of the Imperial Institute.

The first Director of the Imperial Institute was Sir Frederick Abel, Bart., G.C.V.O., K.C.B., F.R.S., who held the office till his death in 1902. He was succeeded by the present Director, Prof. Wyndham Dunstan, M.A., LL.D., F.R.S., who was appointed in 1903.

The principal object of the Institute is to promote the development of the natural resources of all parts of the Empire, and for that purpose it maintains in its Public Exhibition Galleries a permanent exhibition illustrating the natural resources of the overseas Dominions, the Colonies, and India.

In addition the Institute has organised a Scientific and Technical Department to undertake the examination of new or little known Colonial and Indian raw materials, with a view to their industrial use, and to supply information and advice on agriculture, trade and industries of the Colonies and India.

The staff of this department numbers thirty-one, six of whom are geologists engaged in exploratory work abroad in connection with the various mineral surveys now being conducted in the Colonies by the Institute.

The laboratories and stores of this department occupy the whole of the second floor, and parts of the first floor and basement of the west wing of the main building. All the laboratories are equipped on the same general plan.

The working benches are built round the walls, and the centre of each laboratory is occupied by distillation tables, with slate tops, on which all operations requiring a constant water supply are carried out. Each laboratory has its own balance room and fume chamber, and is provided with a covered iron table on which combustions are made, the hot gases being carried away by special ventilation into the chimney stacks.

The furnace room in the west tower is fitted with muffles, a power blast crucible furnace and a pottery furnace, the latter being used for technical trials of pottery clays, of which a considerable number are received for examination. The crusher and mill for grinding ores are also placed in this room.

The machinery room in the basement contains machines for washing rubber, for cutting up grasses, leaves and soft materials, for making rock sections, for cement testing, etc. A copper vacuum pan for concentrating vegetable extracts is also installed here.

Electricity is provided throughout the building, and is used for lighting, for heating Soxhlet extractors, for driving ventilating fans, the ore crusher, grinding mill, magnetic separator, and other necessary machinery.

The Institute is being used to an increasing extent by manufacturers, merchants and traders desirous of finding in the Colonies and India new supplies of raw materials for the industries in which they are interested. In order to deal quickly with such inquiries a "reference sample room" has been

Laboratory No. II.

arranged in which is shown a sample of every important material that has been examined in the department. Each specimen is provided with a printed label giving a brief statement of its origin, composition and possible technical uses, so that it is immediately available for inspection by an inquirer.

Laboratory No. I.

The department also has its own library, which is supplied with all the more important journals and books dealing with subjects coming within the scope of its activities.

The experimental work of the department consists mainly in the examination of natural products, including minerals, fibres, rubbers, oils and oil seeds, volatile oils, foodstuffs and fodders, tobaccos, gums, drugs, tanning materials, etc. These products are chemically examined as they are received, and in every case where the results are sufficiently promising technical trials of the product are made with the co-operation of external expert referees and manufacturers. Finally a report on the composition, commercial value and possible industrial uses of the material is made to the Colonial or Indian Government concerned.

The number of investigations of this kind conducted in 1911 was 635, and 480 reports were made.

The following are a few examples of some of the investigations completed recently. In the course of the mineral survey now being made in Southern Nigeria, under the supervision of the Director of the Imperial Institute, large deposits of lignite or brown coal were discovered. Representative samples of this lignite were collected by the officers of the Survey and forwarded to the Imperial Institute for examination. The analyses made, showed that the lignite was a promising fuel for steam-raising purposes, but that it was inferior to good coal in heating power, and in its raw state had certain other disadvantages. Further experiments showed that by subjecting the lignite to great pressure it could be converted into hard, compact briquettes, and that by this means the calorific value could be largely increased, and practically all the natural disadvantages of the fuel removed. The utilisation of lignite as fuel has been carried to great perfection in Germany and Bohemia, and after careful inquiry in these countries it has been possible to make definite recommendations for the utilisation of this lignite in Southern Nigeria. At present the whole of the West African railways depend on coal imported from Europe at great expense, so that if these lignite deposits can be utilised for the supply of locomotive fuel the building of railways in the country will be facilitated and transport rates can be reduced, to the great advantage of the manufacturer in this country, who depends on cheap supplies of palm oil and other raw materials imported from West Africa.

The Imperial Institute. *Russell & Sons.*

A subject which has especially engaged the attention of the department in recent years is the encouragement of cotton cultivation, particularly in British African Colonies. The British cotton manufacturer requires cotton having certain special qualities. To provide this, experiments in the acclimatisation of the required types of cotton must be made, and if the exotic types degenerate in the new localities, as is often the case, a new type has to be evolved by selection. This part of the work is carried on by the African Colonial Agricultural Departments, and the cottons produced each year in the course of these experiments are sent to the Imperial Institute for examination, with a view to ascertaining which of them best meets manufacturers' requirements.

The above are two examples illustrating the kind of work having a definite industrial object with which the department is mainly occupied; but in addition to this a large number of materials are received for investigation, which involve purely chemical research work. Among these may be mentioned poisonous plants and drugs. Investigations of the former generally arise as the result of poisoning cases among cattle and occasionally among human beings. One of the most interesting plants of this kind examined

Reference Sample Room.

recently is the "ragwort" of South Africa (*Senecio latifolius*), which has long been suspected to be the cause of a curious liver disease in cattle and horses in certain parts of South Africa. From this plant two crystalline alkaloids have been isolated and characterised, and a certain amount of progress has been made in determining the constitution of one of them. Physiological experiments carried out for the Institute by Dr. Cushny at University College, London, conclusively proved that the peculiar liver disease referred to above can be caused by either of these alkaloids, a point of considerable importance, since the origin of the disease was so obscure that in Nova Scotia a similar disease, now believed to be due to another "ragwort" (*Senecio jacobœa*), was formerly regarded as infectious, and made certifiable with a view to its prevention by segregation of the affected animals.

In another South African plant, known as "African yeast," from the fact that it is used by natives in making "Kaffir beer," nearly 3 % of calcium oxalate was found, which is enough to account for certain toxic symptoms occasionally experienced by natives after drinking liquor fermented with the aid of this plant.

A short time since there were a number of cases of acute skin irritation produced in workmen using satinwood in this country. There are two varieties of this timber in use, one obtained from the East Indies and the other from the West Indies. Both these woods have been examined at the Imperial Institute, and from the former a new alkaloid has been isolated which is a powerful irritant. This alkaloid is curiously selective in its action, which explains the fact that out of the large number of workmen using this wood only a few suffer ill effects from it. The West Indian wood was also examined, and from it two crystalline, non-alkaloidal substances have been obtained, as well as a pungent, resinous constituent. None of these is sufficiently irritant to set up skin irritation by itself, but curiously enough certain of them are able to reproduce the symptoms in a patient who has recovered from an attack of the skin disease caused by the East Indian wood.

Some idea of the very varied character of the problems submitted to the Institute may be gathered from the foregoing examples.

A summary of the work done each year is given in the *Report on the Work of the Imperial Institute*, which is issued annually. A selection of the reports on the more important investigations carried out in the department is published in the *Bulletin of the Imperial Institute*, which is now issued quarterly by Mr. John Murray. The reports on particular groups of products are also being printed in a series of "Selected Reports" published in the Miscellaneous Series of Colonial Reports. Of these "Selected Reports" those on rubber and guttapercha, gums and resins, cotton, and foodstuffs have been issued, and others are in preparation.

Machinery Room.

NOTES OF MEETINGS, &c.

THE BRITISH ASSOCIATION.

Section B.—Meeting at Dundee.

Address by Prof. Senier on Organic Chemistry, and the sectional proceedings will also be mainly Organic.

The Subjects are:—

A. Carbohydrates.
    Prof. J. C. Irvine:—(1) Synthetic Aminoglucosides. (2) The Rotatory Power of Partially Methylated Glucosides. (3) The Constitution of Mannitoltriacetene.
    Dr. S. Mills:—(4) Halogen Sugar Derivatives and Synthetic Glucosides.
    Dr. E. F. Armstrong:—(5) Glucoside Synthesis. (6) The Nomenclature of Optically Active Substances.
B. Discussion on the Migration of Groups.
    Dr. A. Mackenzie:—The Walden Inversion.
    Dr. K. J. P. Orton.
    Prof. Senier:—The Relation of Colour to Constitution.
C. Biochemical Papers:—
    Dr. J. V. Eyre:—(1) The Enzymes of *Linum* (flax). (2) Variations in the Flax Plant with Locality.
    A. Crompton:—(3) Action of the Enzymes of Emulsin on Amygdalin and Vicanin.
    F. Neeble and Dr. E. F. Armstrong:—(4) The Biochemistry of Flower Pigmentation.
D. Reports of Research Committees, &c.
    Dr. C. H. Desch:—Diffusion in Solids.
    Dr. J. V. Eyre:—Solubility.
E. Joint meeting with Section A. Subject:—Specific Tests.

Notice of Papers which it is desired to read, accompanied by brief abstracts, should reach Dr. E. F. Armstrong, 98, London Road, Reading, by July 15th, 1912.

THE ALLOTROPY OF SULPHUR.

II. The Isopolymorphism of Sulphur, Selenium and Tellurium.

By T. MARTIN LOWRY, D.Sc. (Lond.).

MUCH additional light is thrown upon the allotropy of sulphur by a comparison of its properties with those of selenium and tellurium. It has been clearly established that these three elements are *isopolymorphous*, *i.e.*, that each element may exist in several crystalline forms, the corresponding forms being isomorphous in the three elements. But, as is usual in such cases, there is a marked difference in the conditions of stability of the forms in the case of the three elements; the low-temperature form of tellurium is isomorphous with the high-temperature form of selenium, whilst the low-temperature forms of selenium appear to correspond with metastable "high-temperature" forms of sulphur.

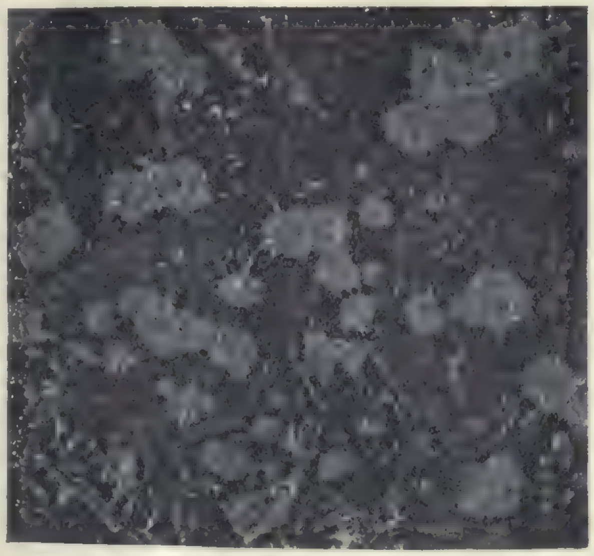


FIG. 6.—CONVERSION OF PRISMATIC INTO ORTHORHOMBIC SULPHUR. (Scale approximately full size.)

Metallic Tellurium, Selenium and Sulphur.—Metallic tellurium crystallises in the rhombohedral system, a system that has not yet been recorded in the case of sulphur. A "metallic" variety of selenium can, however, be prepared by heating the element to redness in a sealed tube. Muthmann showed that, whilst the crystals were too small for accurate measurement, they belonged to the rhombohedral system and had a rhombohedral angle $\alpha = 87^\circ$ (circ.), the corresponding angle for tellurium being 86° 47′. The two elements are, therefore, clearly isopolymorphous. The non-metallic form of tellurium, if it could be discovered, would evidently be stable only at lower temperatures. Conversely, a metallic form of sulphur could only be a high temperature product. Muthmann has suggested that it might be identified with the "black" sulphur of Magnus and of Knapp, prepared by igniting mixtures of sulphur and oil, etc.

Isomorphism of Selenium and Sulphur.—Muthmann was able to prepare three series of mixed crystals:

(1) 100 *to* 67 % Se. These have the ordinary form of non-metallic Se_{I}. Attention has already been directed to the similarity between Se_{I} and S_{IV}. There can therefore be little doubt that the sulphur is here present as S_{IV}, and consequently that S_{IV}, which approaches most nearly to ordinary selenium, must be looked upon as a high-temperature form of sulphur. In practice S_{IV} can only be prepared at low temperatures and in a metastable condition. Its relationship to selenium indicates that it would be the most stable crystalline form of the element only at temperatures above the ordinary melting-point; it is therefore very improbable that it will ever be obtained in a condition of absolute stability.

(2) 60 *to* 35 % Se.—These have the crystalline form of S_{III}. The corresponding form of selenium is unknown, but might be expected to appear on crystallising the element at very low temperatures. The fact that a moderate addition of selenium causes sulphur to separate in stable crystals of the "nacreous" form, suggests that this is again a high-temperature form of the element, and that it is known only in a metastable condition because fusion sets in before the temperature is reached at which it would become the most stable crystalline form.

(3) 35 *to* 0 % Se.—These have the rhombic crystalline form of ordinary sulphur S_{I}. Isomorphous mixtures having the monosymmetric form of S_{II} were not obtained.

Isomorphism of Sulphur, Selenium and Tellurium.—In the following table the axial ratios of all the crystalline forms of these three elements have been collected. The isomorphous forms have been joined together by brackets.

	S_{I}	Orthorhombic	$a:b:c =$	0·81413:1:1·90410.	
	S_{II}	Monosymmetric	$a:b:c =$	0·99575:1:0·99983	$\beta = 84^\circ\ 14'$.
	S_{III}	,,	$a:b:c =$	1·06094:1:0·70944	$\beta = 88^\circ\ 13'$.
⎧	S	,,	$a:b:c =$	?	$\beta = 76\frac{1}{2}^\circ$.
⎩	Se_{I}	,,	$a:b:c =$	1·63495:1:1·6095	$\beta = 75^\circ\ 58'$.
	Se_{II}	,,	$a:b:c =$	1·5916 :1:1·1352	$\beta = 86^\circ\ 56'$.
⎧	Se (metallic)	Rhombohedral	$\alpha = 87^\circ$	$a:c =$ (?).	
⎩	Te	,,	$\alpha = 86^\circ\ 47'$	$a:c =$ 1:1·3298.	

The thermal relationship between the different forms of the elements is shown by the scheme:

In this scheme, isomorphous forms appear in the same vertical column, the forms stable at ordinary temperatures are shown in heavy type, whilst forms which are only known as isomorphous mixtures are shown in italics. The three elements thus form an isohexamorphous series, including one orthorhombic, four monosymmetric and one rhombohedral form. The arrows indicate the direction in which change of crystalline form can actually be observed; double arrows indicate reversible changes.

$$\begin{array}{ccccccccccccc}
 & \text{Ortho.} & & \text{Mono.} & & \text{Mono.} & & \text{Mono.} & & \text{Mono.} & & \text{Rhoml.} & \\
\text{Low Temperature.} & \mathbf{S}_{I} & \rightleftarrows & S_{II} & \leftarrow & S_{III} & \leftarrow & S_{IV} & & & & & \text{High Temperature.} \\
 & \mathit{Se} & — & & -- & \mathit{Se} & \leftarrow & \mathbf{Se}_{I} & \leftarrow & Se_{II} & \rightleftarrows & Se_{MET} & \\
 & & & & & & & & & & & \mathbf{Te}_{MET} &
\end{array}$$

Interconversion of the Different Forms of Sulphur.—Only two of the four crystalline forms of sulphur can exist in a state of absolute stability. The rhombic form S_{I} is stable up to 96°. From 96° to the melting-point the prismatic form is stable; but if the pressure be increased its range of stability is reduced, and at 151° and 1320 kg/cm.[2] the rhombic passes directly into the liquid form (Tammann, *Ann. Physik*, 1899, [3], 68, 633).

The reversible change $S_{I} \rightleftarrows S_{II}$ was shown by Gernez not to be absolutely spontaneous, a nucleus being required to initiate the transformation in either direction. This effect is well seen on melting sulphur in a shallow dish and leaving it exposed to the air; minute, opaque spots are seen after a few hours here and there on the surface; these spots, which consist of sulphur which has changed from the prismatic to the rhombic form, gradually extend until they cover the whole surface. Fig. 6 shows the appearance of the sulphur 20 hours after fusion.

The other forms of sulphur are only known in a metastable condition in which they change readily into S_{I}.

Polymorphism and Polymerism.—The four varieties of sulphur described above resemble each other very closely, and are probably examples of genuine polymorphism, *i.e.*, the crystals are composed of identical molecules marshalled in different ways.[1] Amorphous sulphur, insoluble in carbon disulphide, is almost certainly composed of larger "polymerised" molecules, whilst the rhombohedral form of Engel and Friedel[2] (*Comptes Rendus*, 1891, *112*, 834, 866), soluble in water but quickly becoming insoluble even in carbon disulphide, is probably composed of simpler "depolymerised" molecules. It is proposed to discuss the reversible polymeric changes which sulphur undergoes, especially in the liquid and gaseous state, in a subsequent article under the title "The Dynamic Allotropy of Sulphur."

[1] There is no experimental justification for reducing the four varieties to two, viz., α-Sulphur (orthorhombic) and β-Sulphur (three monosymmetric forms).

[2] A triclinic variety of sulphur, described by Friedel in 1879 in a note of four lines, is not even mentioned in his 1891 paper, and appears to have been "dropped."

THE annual meeting of the Society of Chemical Industry is to be held at the Rumford Hall of the Chemists' Club, 50 East Forty-first Street, New York, on September 3rd.

The Advance of Aluminium in the Chemical Industry.

By RICHARD SELIGMAN, PH.D.

SINCE aluminium was first discovered, nearly a century ago, there have always been those who saw in it a metal destined to play a large part in the manufacture of apparatus for the chemical industry. But even when, some twenty years ago, the metal became reasonably cheap, their hopes seemed as far from realisation as they had been in the early thirties. The amount of aluminium used by chemists was very small, because the apparatus which could be made from it was limited to such articles as could be cast without excessive difficulty and to a few isolated pieces of plant made from riveted sheets, and the disadvantages which both these forms of aluminium offer for chemical purposes prevented a wider introduction of the metal. Pure aluminium was alone sufficiently resistant to corrosion to be used for chemical purposes, but pure aluminium is notoriously difficult to cast solid and free from sponginess. Pure aluminium sheet could be made, but owing to its low yield point and great malleability it does not lend itself as well as copper to riveting, especially where subjected to rapid changes of temperature and vibration, conditions almost inseparable from chemical work. During the last few years means have been found of welding aluminium autogenously in much the same way as lead is burned. From that time the subject has assumed a totally different aspect, and what was formerly impossible, the construction of chemical apparatus of aluminium on a reasonable scale, has not only become possible, but is now a well-established industry. Although it is only about two and a half years since the first welded aluminium vessel was made in this country (it took the form of a vat holding 2,000 gallons) very great progress has been achieved, and quite a number of branches of chemical industry now look to aluminium as the material from which to make their vessels.

The writer in initiating this movement had in view that aluminium would be likely to appeal to each branch of chemical industry on account of some special property which it possesses, and the event has fully justified this view. The advantage which it offers to the brewer is totally distinct from that which the varnish maker finds in the use of aluminium whilst the foodstuff maker and explosives manufacturer select aluminium for very different reasons.

The brewer has been guided to the use of aluminium by the fact that it alone among the common metals does not in any way affect either the life activity of the yeast cell or the taste and brilliancy of beer. Copper, for instance, has been found to act as a poison to yeast, tin renders beer hazy, whilst iron gives a taste which even in quantities of one-seventh of a grain to the gallon is sufficient to spoil the best brew. A number of investigators have pronounced aluminium the ideal material for brewing purposes, the most exhaustive work on the subject being that of Chapman (*Journ. Institute of Brewing*, 1911). The brewing industry uses, as is well known, vessels of enormous size, and their manufacture has made heavy demands upon the new welding processes described above.

The varnish maker has, as his chief object, the preparation of a varnish which is as free from colour as the ingredients used will allow. His aim is to preclude in every way possible discolouration, due to the pots in which his gums and resins are melted. In this he may be considered typical of many manufacturers making such diverse materials as essences, stearines, wax candles, and many pharmaceutical products. In these and similar cases advantage is taken of the fact that the salts of aluminium are without known exception colourless. As a result, varnishes made in aluminium pots are paler in colour than those made in iron, while they are free from the green tinge due to the solution of copper in materials boiled in copper pots. So also many valuable essences which would be ruined if they dissolved small quantities of copper, are now distilled from and stored in aluminium vessels. Here again the welding process referred to above has been of the greatest service, as the joints made by it are capable of withstanding great extremes of temperature without becoming leaky.

The jam maker and the makers of many other foodstuffs use aluminium wherever they can, because they have not to fear the introduction into their products of any poisonous material. Many such materials as fruits and other edible substances readily give rise to acids which attack metals rapidly. If copper is used in their preparation for the market there is always a danger of some of the metal being dissolved and verdigris being formed. Frequent costly scouring is necessary to obviate this danger, and even so a copper jam pan, for instance, cannot be left standing for a few hours without becoming coated with this obnoxious and highly poisonous compound. Aluminium is entirely free from this objection, aluminium compounds having been proved to be entirely harmless.

Reference was made above to the manufacture of explosives, which is typical of a number of branches of chemical industry which use aluminium because it is unattacked by the chemicals used therein. Aluminium is unique among the common metals in its resistance to attack by nitric acid and the mixed nitric and sulphuric acids used for nitrating. For this reason it is recognised as a great factor in solving the difficult problem of handling, conveying and storing these corrosive materials.

Similarly, aluminium is of all the metals the most resistant to the solvent action of the higher fatty acids, stearic, oleic, palmitic acid, etc. To this fact it owes its rapid introduction for the storage tanks, stills, condensers and conveying vessels used in the treating of edible oils and fats. These materials, which form so important a raw material of the margarine and artificial butter manufacturer, are amongst the most difficult to handle, owing to the ease with which they attack metals. At the same time, they are themselves liable to the attack of micro-organisms, so that wooden receptacles, which are porous and may harbour microbes, are ill-suited to contain them. Aluminium is free from both objections, and in America, in Germany, and in England is being used to an ever-increasing degree in the oils and fats trade.

The cases cited above have been selected in order to show briefly what are the considerations which have led to the introduction of aluminium plant into the chemical industry and how rapidly manufacturers are adopting the new metal to their needs now that the difficulties which stood in their way have been overcome.

CORNWALL JOINT SCIENTIFIC RECEPTION COMMITTEE.

President : THE RIGHT HON. LORD ST. LEVAN.

VISIT OF LEARNED AND TECHNICAL SOCIETIES TO CORNWALL, 1912.

(*Provisional Programme.*)

Tuesday, July 16th.—Camborne. Visit the Engineering Works of Messrs. Holman Bros. Leave at 12.30 p.m. for Dolcoath Mine, lunch by invitation of the Directors, and inspect the Mine and Tin-dressing plant in the afternoon.

Wednesday, July 17th.—East Cornwall. The party will visit the various Clay Properties and be entertained at luncheon by Viscount Clifden.

Thursday, July 18th.—Truro and Falmouth. Truro, by 8.30 a.m. train, to visit Royal Institution of Cornwall. Official luncheon. Leave about 3 by special steamboat down the river Fal to Falmouth, drive around the Castle and other points of interest. Tea at Gyllyngdune Gardens, etc.

Friday, July 19th.—Camborne. Mining Schools and King Edward Mine or South Crofty Mine in morning. Visit Messrs. Stephens' Rock Drill Works in afternoon and have tea in grounds.

Saturday, July 20th.—Penzance, etc. Leave Camborne, by 8.35 a.m. train for St. Michael's Mount, by invitation of Lord St. Levan, afterwards being received by Royal Geological Society at Penzance. In the afternoon, the party will proceed to St. Ives and visit the St. Ives Consolidated Mines.

The Great Western Railway Company are issuing a special ticket at £2 0s. 10*d*., to include return fare (third class) from Paddington, and all travelling in Cornwall, except for one short local trip. The ticket will be available from and including Saturday, July 13th, to Monday, the 22nd.

The headquarters of the Committee will be at the Camborne Mining Schools, but hotel accommodation is being arranged, at special rates, at St. Ives and elsewhere for those who wish to live away from a town.

Further particulars will be forwarded to those who intimate their intention to be present for the whole or part of the time covered by the programme. Mr. G. T. Holloway, 13 Emmett Street, Limehouse, London, E., will be pleased to give information pending final particulars from the Secretary of the Committee in Cornwall.

EXHIBITION OF NON-FERROUS METALS.

The increased use of metals other than iron and steel during the past years, throughout the industrial world has been brought home to one by the effective display at the Royal Agricultural Hall, Islington, N.—which constituted during June the first exhibition on record devoted to non-ferrous metals and their alloys. The successful commercial application of such of these as aluminium, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, lead, manganese, magnesium, mercury, nickel, platinum, silver, tin, and zinc, and of the numerous alloys to which they have given rise as the result of experience, is constantly furnishing fresh proof that the profitable employment of metals which are "rare" or apparently useless at present, is practically inevitable under the advance of science. As examples of such scientific curiosities which have lately acquired industrial importance, tantalum, cerium, vanadium, osmium, radium, titanium, selenium and others at once suggest themselves. It is with the unwavering belief in a latent utility, therefore, that every substance must be regarded, despite appearances to the contrary. The alloys of aluminium appear now under the guise of "Duralumin," "Sulphalium," "Vanalium," etc., and form a prominent feature of the exhibits. The first of these (Messrs. Vickers, Ltd.) has a specific gravity of only 2·8 as compared with 7·8 for steel, is unaffected by dampness, mercury, is non-magnetic, practically untouched by sea water or by nitric or sulphuric acids, and is capable of taking a fine finish, varnished with difficulty. These alloys in general combine lightness with special adaptability to casting and machinery, and the second mentioned (Sulphalium Metal Co.) is being used largely on Admiralty work. In common with the less durable parent aluminium, stamping or spinning is performed on annealed metal sheets, which subsequently harden. The exhibit of the British Aluminium Co., Ltd., provides fine examples of mouldings, castings and decorative work in this metal. The specimens of bare aluminium cable for electrical power transmission are of great practical interest in that an ultimate tensile stress of some 40,000 lbs. per square inch, combined with decreased weight of cable, causes a considerable reduction in the cost of installation. The problem of soldering aluminium appears to have been solved in "Mepo" by Messrs. Greenwood & Co., who provide a solder in five grades suitable for all classes of work, a flux being unnecessary, and either an iron or a blowpipe being used.

The applications of metallic "wool" or "ribbon" to pipe-joint caulking, gland packing, and the particular suitability of metals in such form for certain metallurgical operations are important. These products in lead, zinc, copper, brass by the Lead Wool Co., Ltd., are maunfactured in the cold state throughout, and others by the Ribbon Metals Syndicate, Ltd., are claimed to show distinct savings in cost of solders, anti-friction metals and metallic packings. The lead yarn of Messrs. Locke, Lancaster, is a similar material for caulking water and gas mains. By producing true manganese-bronzes (without zinc) of exceptional tensile strength, remarkable maintenance of physical properties at high temperatures, and resistance to corrosive influences and to mechanical wear, the British Mining and Metal Co., Ltd., has set up a standard in these substances which cannot fail to remove much of the existing uncertainty as to the composition and properties of such products.

The production of pure alloys free from carbon is secured by application of the Alumino-Thermic Process (Thermit, Ltd.). Certain standard alloys of manganese and chromium and of many other substances for special purposes illustrate this eminently practical method of eliminating undesirable impurities. Among such products an alloy used for increasing the strengths and ultimate elongations of brasses is important.

The resulting brass has great resistance to atmospheric and corrosive influences, and should recommend itself for many uses. Similar carbon-free metals and alloys are shown by Messrs. H. Ost & Co.

The extension process of manufacturing rods and shaped bars of brass, bronze, and similar metals, which has met with such conspicuous success of late, is exemplified by the products of the Delta Metal Co., with which firm the method originated. Their extended rods and sections in special alloys are striking examples of the revolution effected by the innovation. The high elongation and tenacity of Delta metals (forged or extruded) are now recognised. In connection with such alloys the phosphor-bronze exhibits of Messrs. Chas. Carr, Ltd., and of the Yorkshire Engineering Supplies, Ltd., and the "Eatonia" casting process of the latter firm, are noteworthy. Many varieties of anti-friction ("Babbitt," "Glacier," "Atlas," "Eyre") and other soft metals for special purposes were exhibited, also artistic tin-foil wrappings, and tin-foil for the electrical trade, by Messrs. H. Erhardt & Co., Ltd., and Messrs. Betts & Co., Ltd.

Of the lead, tin and antimony products, litharge, red lead, and white lead, of Messrs. Cookson & Co., Ltd., their new "Chamber" process of white lead manufacture is noticeable as a great advance on the well-known "Stack" method of formation of this substance.

Many fine examples of fancy wire and metal strip or plate work in brass, copper, German silver, and aluminium are provided by various firms, and the use of nickel is extended in one case to the manufacture of cooking utensils.

In connection with the drawn metal tubes, of which there are many specimens, the wire drawing and pointing machines of Messrs. Robertson, Ltd., for wires, or for tube tapering, are worthy of notice as very ingenious and compact. On the mechanical side also the electro-magnetic separators of the Rapid Magnetic Machine Co., Ltd., prove their economy by treatment of waste containing as much as 99% of iron or steel so as to save the 1% of more valuable non-magnetic material. An oil pump utilising the force of surface adhesion, shown by Messrs. Dewrance & Co., is interesting, whilst special battery zincs by the Eyre Smelting Co., Ltd.; a certain product of Messrs. Mabor, Ltd., superceding fire clay, and their cupels for assaying, together with the Hermansen recuperative furnaces, and the unequalled effects of Vanadium as exhibited in steels and bronzes made by the International Vanadium Co., Ltd., are all strong and unmistakable indications of the rapid advances of combined mechanical and chemical science in modern industry.

J. G. D.

The Faraday Society.—The Annual General Meeting of the Faraday Society will be held on July 2nd, at 8.0 p.m. at the Institution of Electrical Engineers. An Ordinary Meeting will subsequently be held, when the following papers will be read:—"Electrocapillary Pulsation of a Meniscus," by A. P. Roshdestwensky and W. C. McC. Lewis, M.A., D.Sc.; "On the Variation of the Conductivity of Aluminium Anode-Films with Temperature," by G. E. Bairsto, M.Sc.

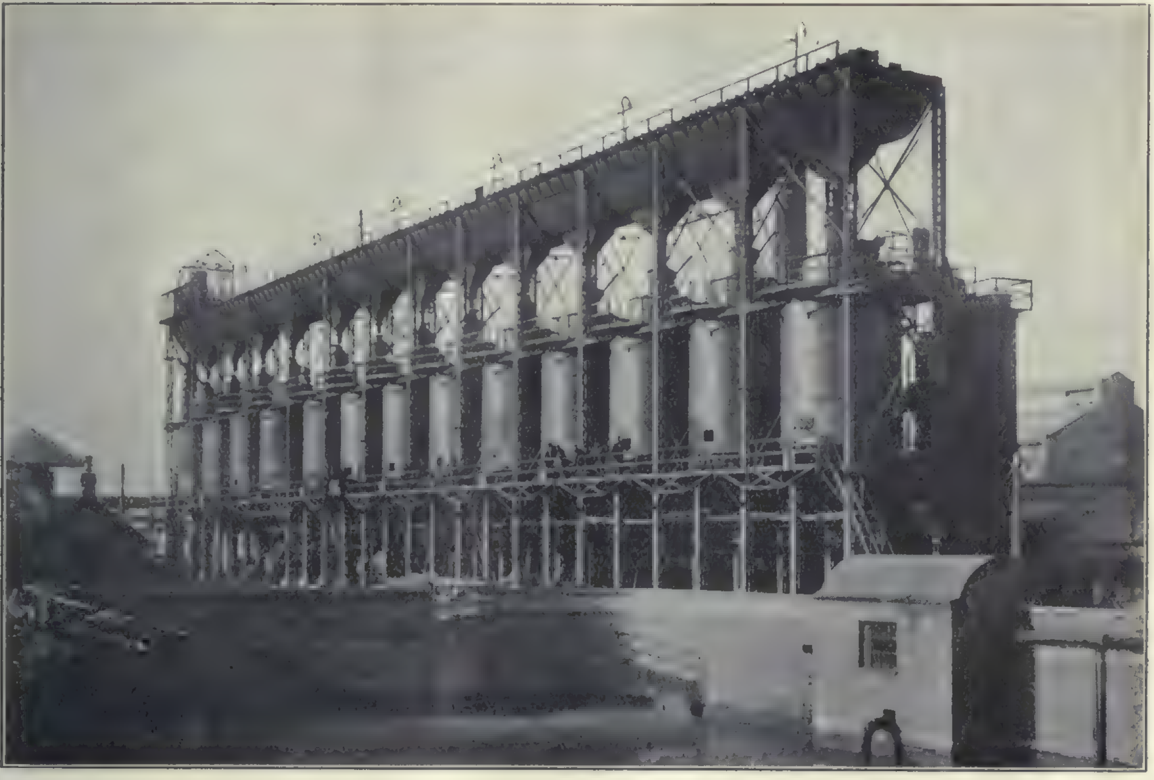
CHEMICAL ENGINEERING.

MOND GAS FOR POWER AND HEATING PURPOSES.

THE subject of power economy is one of general interest to manufacturers, and particulars of the well-known "Mond Gas" for power and heating purposes will illustrate the progress made in this direction.

The late Dr. Ludwig Mond, in 1879, realised that if the ammonia contained in the gas could be conserved and recovered in the process of fuel gasification, great economies could be effected by the users of power and heat. He made countless experiments, and finally patented the Mond Gas Producer. These patent rights were acquired by The Power-Gas Corporation of Stockton-on-Tees and London, who have continued making improvements and additions, which have resulted in the Mond Gas Producer proving the most reliable, economical, and extensively used By-Product Gas Producer in the world.

Owing to the great size of the earlier installation, the idea has become prevalent that the Mond plant is made *only* in very large units. This is not so, as plants from 100 H.P. up to 30,000 H.P. in single units are now being supplied by the makers. Up to 1,000 H.P., however, it does not usually pay to recover by-products.



320-TON WASTE FUEL PLANT.

The class of fuel most commonly used in the Mond Producer is bituminous slack, costing only about 6*s*. to 7*s*. per ton. The Mond Producer, however, is not confined to the use of non-caking fuels, as is the case with the majority of producers available. Mond producers are now at work continuously, gasifying large quantities daily of caking qualities of coals, previously regarded as unusable in gas producers.

The principal by-product of the Mond plant, sulphate of ammonia, finds a ready and constantly growing market amongst agriculturists and farmers, for fertilising purposes, the price ranging from £12 to £15 per ton. In a Mond plant, the sulphate only costs from £3 to £4 per ton to manufacture, and as the yield per ton of coal gasified averages about 90 lbs., or say 4 %, its recovery is very profitable. The consumption of sulphate of ammonia in the United Kingdom has steadily increased during the past ten years from 217,500 tons to over

368,000 tons; the world's consumption during the same period has increased by about 500,000 tons, the total quantity consumed during 1910 being about 1,000,000 tons, and it is confidently expected that the demand for this fertiliser will more than keep pace with the supply.

An important development of The Power-Gas Corporation lies in the utilisation of colliery waste containing a large percentage of ash, which has hitherto been regarded as waste and entirely useless for converting into power and heat. A large Mond plant with by-product recovery, designed to deal with 320 tons per day of waste fuel consisting of colliery waste, belt pickings, etc., containing about 40 % of ash, is now at work. The 13 Mond producers comprised in this important installation are fitted with mechanical ash tables to deal with the high percentage of ash. The gas is being used for firing boilers and driving 3 large gas engines at a big colliery in Staffordshire.

The Mond producer is also at work successfully gasifying coke screenings or ballast, and otherwise waste fuel consisting of the small screenings and sweepings, etc., from coke oven batteries, containing as much as 30 % of ash. From such fuel gasified in Mond producers specially designed for the purpose, a good gas is obtained; at the same time about 70 lbs. of sulphate of ammonia per ton of fuel gasified can be recovered.

The use of producer gas is becoming more general every day, and more particularly so since it is now recognised that gas engines of large units can be relied upon to work efficiently and regularly. Here again, the advantages of the Mond Producer are evidenced by the large installation placed last year by the Imperial Government Railways of Japan with The Power-Gas Corporation, Ltd. This order comprises a complete gas-driven electric generating station of 10,000 kw., and includes three complete Mond Gas Producer Plants (each of 3 units) arranged for the recovery of sulphate of ammonia, together with four large gas engines of 2,400 H.P. each, directly coupled to alternators of the flywheel type. The installation is to supply the necessary current for the electrification of the important railway between Tokyo-Yokohama.

The trains will be fitted with motors, two or more on each coach, and the current will be supplied by means of either a third ground rail or an overhead conductor. The power station will be situated near Yokohama, and there will be two sub-stations with probably a third later on. The power will be conveyed by high tension to the sub-stations, and from there distributed to the railways. The whole installation is to be erected and started to work within two years from the date of contract. The fuel to be used is an inferior quality Japanese coal. The example set by the Imperial Government of Japan should be a means of increasing the confidence of the Japanese generally in producer gas.

For heating purposes, Mond gas is without doubt the cheapest gas made per unit of heat, and in addition it has many advantages over direct coal firing; higher temperatures are attainable, the

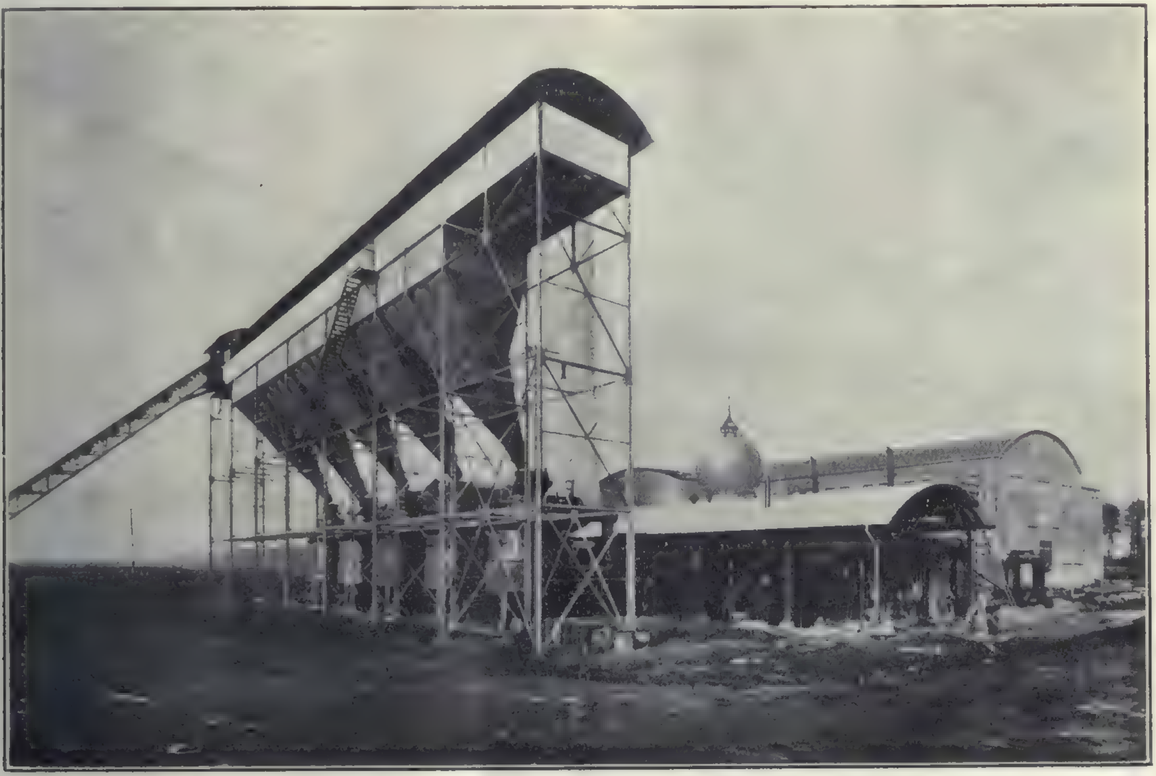
100-ton Mond Ammonia Recovery Plant used for Firing Chrome Furnaces.

smoke nuisance is eliminated, labour is much reduced, and complete control of the flame is obtained.

The utilisation of peat and brown coals is a question which has occupied the minds of many leading engineers for years past, but The Power-Gas Corporation claim to be the first firm successfully gasifying wet peat—containing up to 70 % moisture—on a commercial scale. It is well known that the utilisation of peat in a fairly dry state does not present any difficulties, but since peat as dug contains approximately 90 % of moisture, and as (in spite of more than 50 years' investigations by eminent scientists) no economical apparatus has yet been devised for mechanically drying it, the successful utilisation of peat depended on being able to use it in a comparatively wet state. Peat containing 60 to 70 % of water can be produced in most countries at all seasons except the depth of winter, by a brief period of air drying. The Mond Gas Producer Plant is claimed to be the only gas plant on the market able to satisfactorily use peat containing 60 to 70 % of water.

The following list of some of the peat plants installed will give some idea of what has been done in this respect :—

1. A 20-ton plant erected in Westphalia, Germany, to demonstrate the utility of the process as worked out by The Power-Gas Corporation. This plant so interested the German Government that under the auspices of the Minister of Agriculture for Prussia large trials were carried out, under bye-product recovery conditions, by officials of The Power-Gas Corporation with peat emanating from the extensive bogs of Hannover and Oldenburg as representative of North Germany. So successful were these tests that the under-mentioned plant at Osnabruck was installed, viz :—
2. A large central electric station upon a peat bog 25 miles from Osnabruck (Hannover), and this important town has shut down its steam-driven station and is now taking current transmitted at 30,000 volts and generated by Mond gas from peat at the bog station. The gas plant here is capable of gasifying and recovering the by-products from 210 tons per day of 24 hours of air-dried peat containing 60 % of moisture. The gas is supplied to four double-acting tandem gas engines, each of 1,150 B.H.P. coupled to alternators which are run in parallel. The current is also distributed over an area of about 25 miles radius as well as to Osnabruck.
3. An electric central station situated near Orentano (Lucca, Italy), where Mond gas is generated and by-products recovered from about 100 tons of peat per day. Part of the gas is used in three 500 B.H.P. double-acting gas engines driving alternators in parallel. The current is distributed over the



210-TON PEAT PLANT AT OSNABRUCK, HANNOVER.

surrounding district and to the town of Pontedera, 14 miles away from the plant. The supply has been uninterrupted since the starting of the plant two years ago, and it is worthy of note that the results obtained have considerably exceeded the guarantees given by The Power-Gas Corporation, and more than fulfilled the stringent conditions of the contract. The peat used contains 1·45% of nitrogen, and is yielding over a cwt. of sulphate of ammonia per ton of theoretically dry peat.

4. A cotton mill near Moscow is at work, gas driven by a 300 H.P. engine. The gas for the engine is generated from Russian peat, containing up to 30% moisture, in a semi-bituminous non-recovery plant installed by The Power-Gas Corporation.

The plant installed in Italy has proved so successful that a further order for large peat ammonia recovery gas plant has just been placed with The Power-Gas Corporation, Ltd., the plant being designed to gasify 150 tons per day of peat containing about 30% moisture.

To firms having a supply of wood waste or sawdust, a plant to dispose of this refuse and provide the necessary power for the works will be of great interest. The Power-Gas Corporation have specially designed a plant for this purpose, and are able to guarantee the satisfactory and continuous running of their plants on these materials. For plants of smaller sizes from 30 H.P. upwards, they install their special S.P.B. plants, and for large plants from 150 H.P. upwards the "Mond" type.

Many firms claim to have solved the problem of gasifying sawdust, and The Power-Gas Corporation not only claim this distinction, but are able to show actual installations at work. Their plants to use wood and sawdust are now at work in England, Scotland, South Wales, and many such installations have been erected abroad.

In addition to their well-known Mond plants, The Power-Gas Corporation manufacture suction and suction-pressure plants to gasify anthracite, coke and charcoal. These plants are claimed to possess special advantages over the ordinary type of suction plant.

The suction producer is, of course, practically limited to driving engines, but where gas is required not only for driving an engine, but for small heating and furnace work, the suction-pressure is most useful.

In conclusion, the Power-Gas Corporation have during the past 25 years naturally tested fuels from all parts of the world, and thus have at their disposal information regarding the practicability of the better-known coals etc., for gas producing purposes. This information enables them to advise intending purchasers as to the most suitable and efficient kind of plant to employ.

THE PERMUTIT SYSTEM OF WATER TREATMENT.

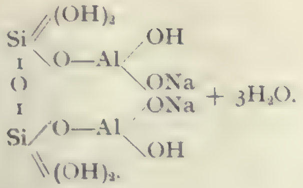
By L. H. Harrison, M.Sc., Ph.D.

The question of water softening and of water treatment in general is attracting the attention of manufacturers more and more every day, and the long list of purification processes on the market is being constantly added to. In the field of water softening alone, for example, one can mention off-hand a dozen types of machine which are in use with more or less success in the industrial centres of this country. Practically every one of these machines works on the same fundamental chemical principle, and the variations in the systems are due merely to differences in the mode of application of the chemicals and to various more or less important changes of a purely mechanical nature. Of late years a new system has been evolved based chiefly on the work of Professor Gans, of Berlin, and it is this system, working on an absolutely new principle, which bids fair to revolutionise our modern methods of water treatment.

The advance of this last-named process into high favour in the industrial world has been extremely rapid, and already on the Continent some hundreds of plants are in use, while one installation alone near Bremen is treating a matter of some 3½ millions of gallons of water per day. This popularity of the system is the more remarkable in face of the fact that only a few years ago the active chemical material known technically as Permutit was only a laboratory product.

As already explained, it is Professor Gans to whom we owe the discovery and development of the principle on which the Permutit processes are based. The Permutits, as we know them, are all complex silicates containing as a constant constituent some proportion of aluminium. To the inorganic chemist to-day there is, perhaps, no field of study more difficult than that devoted to silicates and felspars. To deal with these substances we have to have recourse to melting processes, and the high temperatures necessary and the complexity of the constituents have together militated against much advance in our knowledge of the constitution of the silicates. Dr. Gans has recognised various classes of silicates and has invented a workable hypothesis by which he explains their chemical behaviour. By melting together soda, china clay and some other ingredients in certain proportions, Dr. Gans obtained an artificial aluminium silicate which possessed properties which similar natural silicates possessed only in very minute degree. A careful comparison of the behaviour of the silicates led him to the conclusion that in the natural silicates the sodium or potassium base was joined direct on to the silicic acid—the atoms of hydrogen of the latter being replaced in the usual way by metals. On the other hand the artificial product differed from this in that the base was joined on to the silicic acid through the medium of alumina. The graphic formula of a simple artificial aluminium silicate of the empirical formula

$Na_2O.Al_2O_3.2SiO_2 6H_2O$, would then be somewhat as follows :—



Gans named these bodies " Permutits " from the Latin root " permutare " = " to exchange," as by this name he gave expression to a most important power which they possess—namely, the property of exchanging their bases. Let us take, for example, Sodium Permutit, the most widely known of the Permutits. It contains aluminium and silica with the base sodium. If now we pour over this a solution containing calcium, the sodium is driven out by the calcium and Calcium Permutit is formed, the sodium going off in solution united to the acid radicle originally joined on to the calcium. Conversely by acting on Calcium Permutit by a sodium salt in excess, Sodium Permutit is re-formed, the calcium being expelled.

The Sodium Permutit of commerce is made by melting together various clayey bodies and soda, the resultant glass being then crushed, hydrated and washed repeatedly. It is then screened, dried in centrifugal machines and stored moist. The finished product is of a grey, mother-of-pearl lustre and quite insoluble in water.

The properties of exchange mentioned above are those on which is based the use of Permutit in water softening. Hard waters contain salts of lime and magnesia—chiefly bi-carbonates, sulphates or chlorides. To these salts are due all the soap destroying effects, boiler scale formation, and the many other disagreeable qualities of a hard water.

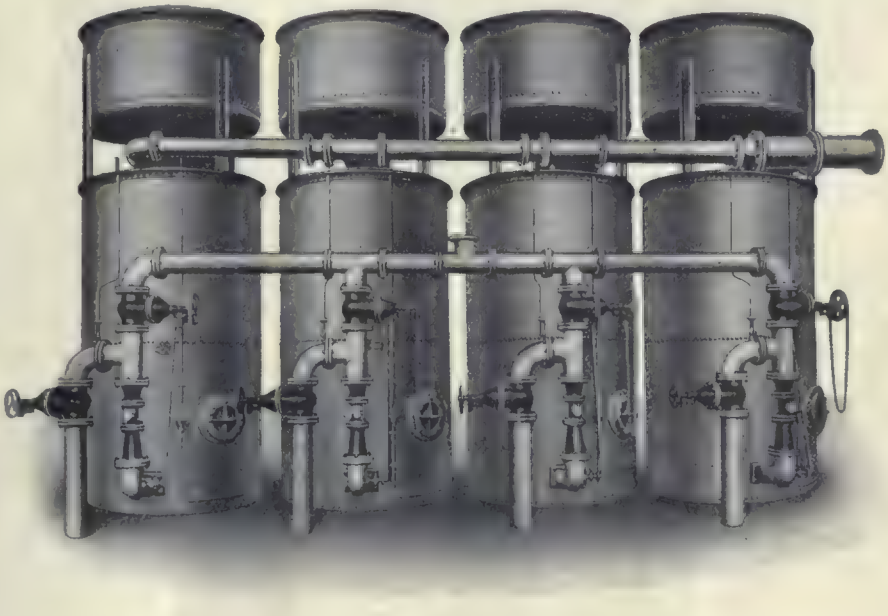


FIG. 1.

Suppose now we allow a hard water to flow through a bed of Sodium Permutit. Just as explained above the lime and magnesia in the water displace the sodium of the Sodium Permutit forming Calcium or Magnesium Permutit, while the sodium goes away in the water as soluble sodium salts.

Calling the acid radicle of the Sodium Permutit P, the softening action of Permutit is expressed by the following equations :—

$$Na_2P+CaSO_4=Na_2SO_4+Ca.P.$$
$$Na_2P+MgCl_2=2NaCl+Mg.P.$$
$$Na_2P+CaH_2(CO_3)_2=2NaHCO_3+Ca.P.$$

etc., etc.,

In practice, this exchange is absolutely complete. A water charged with a lime salt will come out after filtration absolutely lime-free and magnesia-free, and will contain no scale-forming, soap-destroying or other injurious ingredients. Treated with ammonium oxalate, for example, the treated water remains quite clear, while if tested in the usual way with soap solution the water will be shown to be of zero degrees of hardness. This property of exchange may be shown in striking fashion by taking a water saturated with calcium sulphate. Such a water gives a thick curdy mass with soap solution—for example, the Boutron-Boudet solution—and it is impossible to estimate the hardness accurately. Let the water now pass through Permutit and it will be found that with 40 c.cm. of treated water 3-5 drops of soap solution produce a lasting lather. The water is a " zero " water.

In course of time obviously the Sodium Permutit with which we began will have all its sodium displaced and will have become a Lime-magnesia Permutit in accordance with the equations given above. Lime-magnesia Permutit has naturally no effect on hard water. Use it now once again made of the " base exchange " property of the Permutits. Through the bed of Lime-magnesia Permutit allow a solution of common salt to flow. Then the sodium of the salt replaces the calcium and magnesium of the Calcium Permutit, forming Sodium Permutit again, while the calcium combines with the chlorine of the salt according to the equation :—

$$CaP+2NaCl=CaCl_2+Na_2P.$$

It is then only necessary to wash away the excess of salt and the expelled $CaCl_2$ and we are left with a bed of Sodium Permutit ready for work again. In the process of softening then, the following cycle goes on indefinitely :

In *Working*. Sodium Permutit+Hard Water (=Calcium Salts)=Calcium Permutit+Sodium Salts (soluble).

In *Regeneration*. Calcium Permutit+Sodium Chloride=Calcium chloride+Sodium Permutit.

The softener consists of a cylindrical tank containing a bed of Sodium Permutit between two layers of gravel. A battery of four units is shown in the accompanying illustration, Fig. 1. The hard water enters at the top and percolates downwards, the rate of flow being adjusted so that a zero water flows away underneath. A given weight of Permutit treats an amount of water varying, of course, directly with the hardness. When the specified amount of crude water has passed through, the inlet is closed and the flow of water is reversed for a minute or so. This reversal of flow breaks up the bed and prevents formation of channels, expels air, etc., which may have collected in the pores. The filter thus cleansed is ready for regeneration. Above the cylindrical tank is another tank into which the necessary amount of salt is introduced and dissolved in water. This solution is run in on to the Permutit, and the outlet cocks are so arranged that the salt solution flows through in about six to eight hours. At the end of this time the salt valves are closed and the filter is washed free from chlorides. It is then ready for work again.

The softener may be of the open or closed (pressure) type. By having a lid bolted on, as in the pressure type it can be put anywhere in the water supply circuit. This is an advantage. The whole arrangement is very simple, and there are no moving parts or proportioning gear. Common salt is the only reagent used, and is not of the same objectionable nature as lime or soda. The water coming out is of exactly the same alkalinity as that entering, except that it contains no lime. It requires just as much acid to acidify it before treatment as after treatment. This is an important point. The treated water is of the same reaction entirely. The lime goes away in washing as soluble chloride of calcium, so there is no sludge to dispose of and no settling tanks or filters are necessary. In every other softener precipitation methods are resorted to—calcium salts having to be precipitated by lime or soda added in specified quantities—producing disagreeable precipitates of calcium carbonate, etc., which have to be mechanically removed. In such machines large clumsy settling tanks are necessary, and a fine adjustment of the quantity of chemicals added is indispensable.

Permutit water has the advantage of being of uniform quality. It is zero all the time. Suppose a plant is designed to treat a maximum of say 10,000 gallons. Then enough Permutit is put into the filter bed to remove the lime from 10,000 gallons, so that from start to finish an absolutely lime-free water is produced. Such a uniformity is of great advantage in every factory, and there is no continual adjustment of chemicals necessary to obtain this end. In the case of a lime-soda plant the hardness rarely falls below 3-4 degrees unless an excess of reagent is added, which is in itself a serious objection.

In this paper I shall deal with only one other member of the Permutit series—namely, the product known as Manganese-Permutit. It is possible to replace the sodium in Permutit by manganese and so form a Manganese-Permutit. This is a silicate of exactly the same porous and amorphous nature as the other Permutits. If now we act on this substance with a dilute solution of potassium permanganate, the manganese element in the Permutit is oxidised to the higher oxides of manganese and Potassium Permutit is formed. These oxides of manganese are precipitated in an extremely fine state of division in and on the Permutit, and the whole mass becomes black or brown. This mass is very rich in oxygen and is a very powerful oxidising agent, being composed of mixtures of several of the higher oxides. If now this manganese Permutit, as it is called, be allowed to act upon easily oxidisable matter, the latter is immediately oxidised at the expense of some of the oxygen in the Permutit. In time, naturally, all the oxygen is used up; it is then only necessary to recharge the mass with oxygen by allowing a solution of potassium permanganate to flow slowly through it. This regenerates the Permutit, yielding up its oxygen to it and making it highly active again. This is the analogous process to the regeneration by salt, in the case of Sodium-Permutit in water softening.

This property which Manganese Permutit has, of assimilating oxygen and yielding it up again readily, has been turned to account on an industrial scale for the removal of iron from waters, for the removal of manganese in any form from waters, and for the sterilisation of water.

Suppose we have a filter filled with Manganese-Permutit, and we filter water containing iron through it. The iron is oxidised by the high oxides of manganese which are precipitated in the Permutit. Oxide of iron is thereby precipitated in the upper layers of the filter bed, and a water chemically free from iron passes through. There are no traces left, and the water is not only, as we say, commercially free from iron, but absolutely so. In time, of course, if we pour more iron solution through, we should use up all the oxygen from the active oxidation material, and we would then have to regenerate. In practice the filters are all built of a pressure type with stirrers inside to prevent choking up by the precipitate of iron. In form the filters are practically the same as the softeners, there being the usual regeneration tank, this time for $KMnO_4$. When regeneration is necessary we have first to close the inlet cocks and wash from the bottom upwards for some time, thus washing away the accumulated mud of iron oxide. When the outflow is clear we begin regenerating, allowing the $KMnO_4$ solution to flow slowly through the bed. At first the outflowing liquid will be quite clear and colourless. This indicates that the potassium permanganate is being acted upon and discoloured in the filter bed. In point of fact, the exhausted Permutit is acting on it, precipitating all the manganese out of it as higher oxide of manganese, and a manganese-free water is flowing through. This process of regeneration can be readily demonstrated. If we take a filter which has been used somewhat and pour permanganate through, the liquid will come out clear and free from manganese. The more oxides of manganese we get in the filter, the better it is, for they easily oxidise on regeneration and yield thereby a larger amount of available oxygen. In one particular filter the activity had risen ten-fold after ten regenerations. Some waters containing much organic matter and much iron combined with organic acids are particularly hard to treat. To such as these it is customary to add dilute potash permanganate solution in the form of drops to the crude water. This is easily done, the $KMnO_4$ being sucked in by the flow of crude water in the inlet piping. This permanganate acts upon organic matter, colloidal oxides of manganese are formed, and aid in the deposition of the iron. The last traces of the excess of manganese or permanganate are, of course, subsequently removed by the Permutit.

Sterilisation of water by Manganese-Permutit is also carried out in this way. Very many waters do not become sufficiently sterilised by simple filtration, especially when there is much organic matter present which uses up the oxidising agents and oxygen in the water. In sterilisation by Permutit, permanganates are added to the water; these help in the killing of the germs and produce in presence of manganese salts colloidal hydroxides, which precipitate and coagulate all harmful organic matter. Any excess of permanganate is removed on filtering through Manganese Permutit.

The main interest, however, which Manganese-Permutit has in the industrial world is on account of the facility with which it removes iron. As already stated, we get a water after filtration absolutely free from iron. There can be no danger to manufacturers from iron stains which have a way, when traces of iron are present, of developing long after finishing the goods.

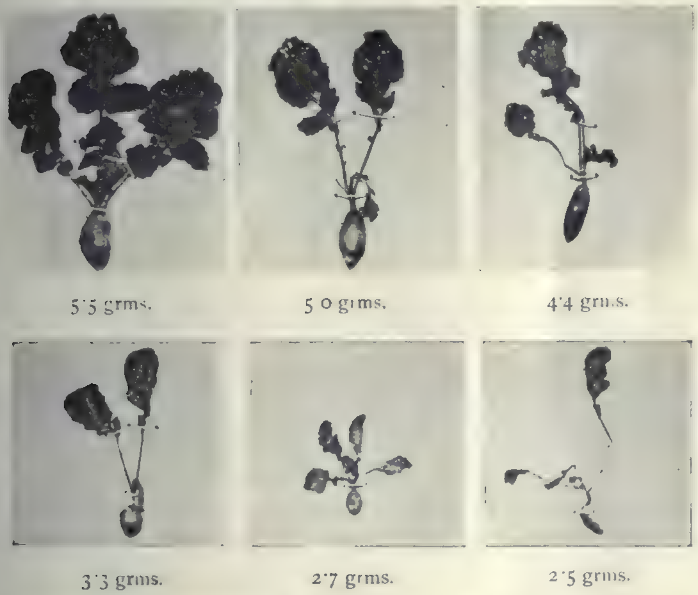
REVIEWS OF BOOKS.

"SMOKE." By Julius B. Cohen and Arthur G. Ruston.

EDWARD ARNOLD, London, 1912. Pages 88, including Index and Appendices, 35 Illustrations with Frontispiece. Price 5/- net.

IT is well known that Professor Cohen has spent much time in the study of the ill-effect of the products of the modern furnace and shaft on vegetation, and the authors have collected the results obtained by those who have also interested themselves in this question, in book form, thus facilitating reference to observed facts.

Professor O. N. Witt's contention that "Smoking chimneys are thieves, and their misdeeds should not rise unavenged to Heaven," is possibly true in more ways then one. Although there is no very direct evidence of the deleterious effect of its influence on general health, the authors seem to think that this is a factor which must be considered. In this connection it must be remembered that some of the products are distinctly antiseptic in their nature, and it may be found, when the figures of soot production are realised, that the amount of sulphuric acid, etc., present in the atmosphere, may indirectly have some beneficial effect in purifying the air from bacterial life, and thus to an extent compensate for its ill-effects in other directions. Even if this is so, the irrational way of applying the remedy will be evident to all.



5·5 grms. 5·0 grms. 4·4 grms.

3·3 grms. 2·7 grms. 2·5 grms.

FIG. 1.—PHOTOGRAPHS OF RADISHES GROWN AT DIFFERENT CENTRES WITH WEIGHTS.

The subject matter is divided into sections dealing with the solid products of combustion and gaseous impurities respectively. The amount of soot emitted from chimneys, daily soot fall, effects of soot on vegetation, and the intensity of light, the effect of sulphuric acid on masonry, metal work, and vegetation, are discussed at length. One of the accompanying illustrations well illustrates the effect of the latter. The fact that apparently 76,000 tons of soot fall on London every year shows that the matter is serious enough for the attention of all. The only redeeming point is that the rain in that district is hardly ever acid. This is ascribed to the absence of foundries and chemical works. We have been informed that some unpublished figures indicate that the week-end is the time of the greatest deposition. Cooking the Sunday dinner in innumerable houses is said to be the cause of this increase. In fact, figures given clearly indicate that the house-wife is directly responsible for a great proportion of the effect produced in the London district. The open grate must be completely abolished before any real advance can be expected in large towns.

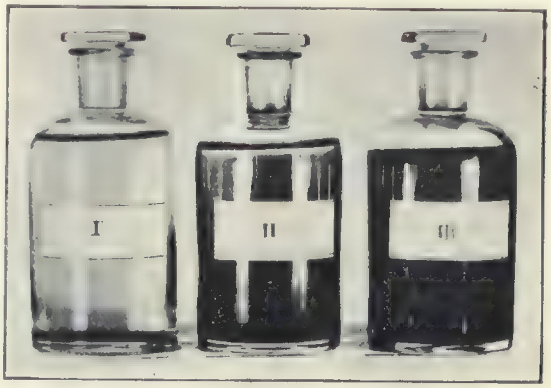


FIG 2. I. RAIN-WATER: II. MELTED SNOW BEFORE FOG; AND III. AFTER FOG.

"BLEACHING AND DYEING OF VEGETABLE FIBROUS MATERIALS." By Julius Hubner.

CONSTABLE & CO. LTD., London, 1912. Pages 434 + xiii, including Index. Parts 18, with 96 Illustrations. Price 14/- net.

This work, like certain others of its type, deals entirely with the practical side of an industry, but this condition is not often so definitely followed as on the present occasion. As a consequence, its general usefulness is correspondingly circumscribed. Its general value to the student as a text-book is lessened. It is an increasingly difficult task to set up a condition of "practical utility and practice minus theory" especially in an industry which has, although empirical in ways, been developed on research. This ultra-practical position should not in our opinion be put too forcibly before students, who have to make their way in the world under conditions which must exist in the future.

The space devoted to such subjects as water analysis, lists of well-known chemicals, and their prices (sometimes erroneously given, and always to be found in any trade paper) might very well have been taken up by far more important matters, *i.e.*, the nature of the reactions involved in the actual processes. The general position has become so complex under modern conditions, that the absence of any knowledge of theory will often seriously handicap the dyer.

The essentially practical, or commercial, nature of the general scheme followed has led, for instance, to the inclusion of a series of pages of selected names of trade dyestuffs (many of them probably mixtures) which are presented to the bewildered eyes of the general reader. These, and the illustrations of machinery of certain construction are placed before the student on a " take these and dye " principle. Such a system leaves the higher consideration of theory in the hands of the dye manufacturer and machinist; and simply regards their products as " raw materials " to be used on an industrial scale.

This policy has unfortunately been fostered in this country to a degree. The enterprise and acumen of the dye manufacturers who supply the industry with new products (under trade names), and give practical instructions for their application has in its effect done much to destroy initiation in the dye-house. Thus the future development of this industry has been automatically placed in the hands of the dye manufacturers—which is perhaps as they desire it. We have seemingly reached a point, as in this text-book, where theory has been entirely " cut out," and the reader receives the impression that the practical side of the question is the only one worth considering. We believe this to be a fundamental error in a book which under different conditions might be a useful text-book for the student.

It is evident that such a method as a basis of instruction must stand or fall on its merits, for it cannot conveniently be correlated with one which has a definite scientific basis. The effect of the concurrent study of the two systems on the student's mind would not be beneficial to progress. As a general text-book the work cannot be recommended. As an account of actual progress of operations in vogue to-day in the industry, it has a distinct value.

On page 15, under the heading of water analysis, will be found a series of tests for the presence of calcium, chlorine, etc., which are generally used in ordinary qualitative analysis. These have been given as applicable to water analysis. It is questionable whether these would be of any value in many cases, or that they could generally be used for the detection of these impurities. In testing the hardness of waters the soap test is the only one given. More modern and correct methods have been passed over. The particulars concerning the softening of water on a commercial scale are meagre; and the method of giving a more or less detailed account (illustrated) of a firm's special apparatus to illustrate it, is not one which can be praised in a book of this general nature.. The much-discussed and modern Permutit process is not even mentioned.

Generally speaking, the illustrations are above the average, and in some of the plates the actual course taken by the fabric is shown in red, thus making it easier for the tyro or general reader to follow its course, and saving a certain amount of description in the text. The chapter on the analysis of dyestuffs is hardly satisfactory. In the case of Violet dyestuffs, for instance, only six dyes are tabulated out of the large number on the market. Exactly what would happen if a student went through these tables when testing on general lines can only be surmised.

An appendix contains a series of tables dealing with such subjects as conversion tables, English weights and measures, weight of pipes, number of teeth, and other matters which seem out of place in such a book. These rightly belong to the many sets of tables dealing with such matters.

This work has been criticised in some detail, because it seems to have in it the elements of a satisfactory text-book. If in the next edition, which the author has already promised, certain alterations are made, and its exceedingly commercial type modified, and practice connected with theory, it should then become as useful to the student as to the general reader.

"CHEMICAL WORKS: THEIR DESIGN, ERECTION, AND EQUIPMENT." By S. S. Dyson and S. S. Clarkson. SCOTT, GREENWOOD & SON, London, 1912. Pages 207 + ix, including Index and Appendices. Chapters XI., including 80 Illustrations and 9 Plates. Price 21/- net.

The authors claim that they have not attempted to add to those existing text-books on chemical engineering, which are for the most part handbooks dealing with theoretical design. The drawings, which are a feature of this book, are claimed to be actual working ones, used when designing chemical plant over a number of years. This is certainly a satisfactory feature, and one which is to be altogether commended. It is claimed that the subject-matter has been written as a result of twenty years actual experience.

This work deals with the question of choice of site—a most important point. One has only to notice in this country the haphazard way in which certain industries have been located to immediately appreciate this. The textile industry in the Eastern Counties is a case in point, and one which continues in spite of difficulties. A further case in Germany is one which might be mentioned. A change from one side of a town to the other with an altered water supply gave the business in question a leading position in its particular line. Materials used in construction, laying-out of works, and the Power-house are next considered.

The remaining part of the book is devoted to special industries, and deals with sulphuric, hydrochloric, and nitric acid plants, with special hints concerning high explosives, sulphate of ammonia, artificial manure, and general plant.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By EMIL HATSCHEK.

CHAPTER VI.—(*Continued*).

THE optical behaviour and the ultra-microscopic appearance of the emulsoids require only passing reference. The sols are all either slightly turbid or at least opalescent and show a marked Tyndall cone. In the ultra-microscope they cannot generally be resolved, that is, they show no particles, but only diffused light. As, apart from possessing a minimum size, particles to be visible must differ either in colour or in refractive index from the dispersion medium, their absence is easily accounted for: the difference between the two phases—a concentrated disperse and a dilute continuous phase—may conceivably be very slight.

While there is thus a fairly sharp demarcation between the suspensoids and the emulsoids, there is a very gradual transition from the latter to true solutions. We know a whole range of substances the colloidal character of which is less and less marked, appears only in certain solvents or at certain concentrations, and is often confined to one or the other characteristic of emulsoid sols. Among these semi-colloids may be mentioned the soaps—*i.e.*, the oleates, stearates and palmitates of the alkalies. In dilute aqueous solution they show a slight lowering of the vapour tension, which decreases with increasing concentration and disappears entirely at about one mole (about 28% of sodium palmitate). At that concentration we have a typical emulsoid sol, which sets to a jelly on cooling and can be "salted out," as is, indeed, done industrially. In alcoholic solution, on the other hand, the soaps show normal raising of the boiling point and all characteristics of true solutions. Tannin behaves somewhat similarly: the aqueous solution is turbid, froths, does not diffuse through parchment and shows no lowering of the freezing point, whereas in glacial acetic acid it is in true solution.

The colloidal character is still less marked in some of the products of cleavage of albumin, for instance in the peptones. They diffuse slowly but appreciably and show perceptible lowering of the freezing point: the only properties which link them to the emulsoids are slight turbidity and the syrup consistence which they assume with increasing concentration.

The dyestuffs, finally, show every possible variety of behaviour. Many of them, like eosin and methylene blue, show "optically empty" in the ultra-microscope, diffuse and lower the freezing point normally. Others, like congo red or benzopurpurin, do not diffuse and show particles. Others again have emulsoid character, like fuchsin, which in concentrated solutions forms membranes on the surface and can be "salted out" with concentrated sodium chloride. A very exhaustive investigation of fifty dyestuffs of the indicator class has recently been completed by Wolfgang Ostwald, from which it appears that in practically all cases either the base or the acid, if not the dye itself, shows particles or at least a cone in the ultra-microscope.

CHAPTER VII.

REFERENCE has already been made in the preceding chapter to the changes which sols like those of gelatine and agar undergo on cooling, or which takes place in silicic acid sol on standing or the addition of electrolytes. The sols in these conditions set to coherent gels without loss of water and notwithstanding the very large amount of the latter present in some of them—2% agar makes a very stiff gel—they possess some of the properties of solids. This very striking fact, which at first sight is inexplicable, becomes intelligible to some extent when we remember organic structures, like the stems of plants, which show considerable rigidity and elasticity although containing 80 to 90% of water; these qualities are due to the liquid being enclosed in cells and vessels. We are probably not straining the analogy too much when we assume, even without further evidence—of which there is a considerable amount—that the gels must have some structure of this kind, that is to say, the liquid must be enclosed in cells formed by a solid phase. We shall return to this important question after the discussion of a few typical cases.

The gels are generally divided into "elastic" and "rigid" gels, gelatine, agar, the nitrocellulose-gels belonging to the former class, while silicic acid gel is the chief representative of the latter. The terms are not strictly correct, as the silicic acid gel can be felt to vibrate when the vessel containing it is struck, and must therefore possess some degree of elasticity, but they are sufficiently descriptive to be generally accepted. The silicic acid gel can be obtained in its pure form by allowing a dialysed sol to set (a process which can be very much accelerated by bubbling carbon dioxide through it for a short time) and then forms an almost clear, faintly bluish jelly, containing up to 30 moles of water for one of SiO_2, *i.e.*, about 90% of the total weight of the gel. If a slight excess of waterglass solution of about 1·16 sp. gr. is added to hydrochloric acid containing about 8% HCl, the mixture sets almost immediately to a white opaque gel, which of course contains the excess of sodium silicate and the sodium chloride formed by the reaction, but may nevertheless be used to demonstrate many of the properties of the gel.

The pure gel, if left in air, rapidly loses water even at ordinary temperature, but still retains several moles. These can be removed by drying over sulphuric acid, and the course of dehydration has been studied by van Bemmelen in a series of most exhaustive and careful experiments, prolonged in one instance for two years. The gels were kept in desiccators over sulphuric acid of known concentration and, therefore, vapour tension, and weighed at frequent intervals. The re-hydration was also investigated, and the complete results covering the range from 3 to 0 moles of water are plotted in Fig. 9 in which the abscissæ are the vapour tensions in mm. of mercury, and the ordinates the amount of water in moles.

The most important point brought out is that—with the possible exception of the range between one and two moles, corresponding to meta- and orthosilicic acids—there are no definite hydrates, but that there is a continuous loss of water and an equilibrium corresponding to every given vapour tension. In this respect the gel differs radically from, say, crystals with water of crystallisation. Copper sulphate, *e.g.*, crystallises with 5 molecules of water: four of these are given off at 100° and the fifth at 200°. A dehydration curve plotted with the temperatures as abscissæ and the water contents as ordinates would therefore consist of two vertical lines—the process is discontinuous.

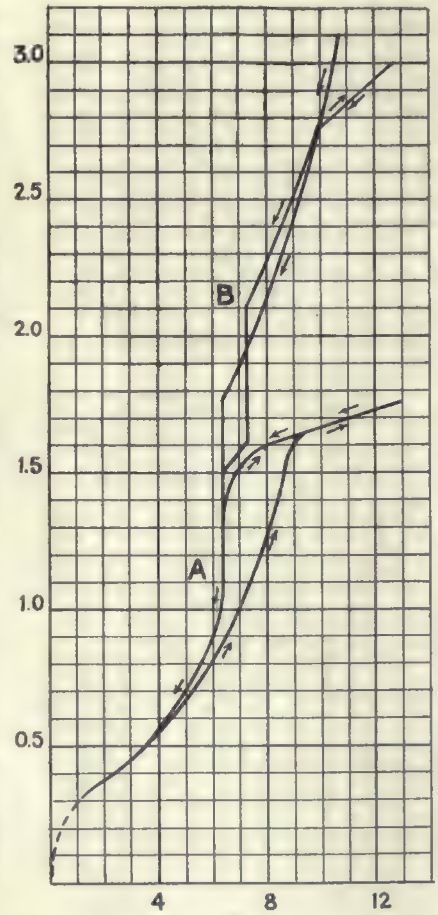


FIG. 9.

We meet here for the first time a class of compounds which are quite definite under given conditions, but in which the ratio of the constituents can change *continuously*, and not only by steps corresponding to simple stoichiometric ratios. Such compounds, known as "adsorption compounds" are of enormous importance in nature, and will be further considered in connection with the laws of adsorption.

The gel gradually undergoes a striking change in appearance during drying, which deserves mention, as it throws some light on the question of gel structure. At A the gel is still bluish and translucent, while at B it becomes chalky-white and opaque. On still further drying, however, it becomes clear again, and is almost transparent in the last part of the dehydration curve. We shall again refer to the probable meaning of these changes.

The elastic gels, like gelatine, have not been investigated in the same exhaustive manner, but ordinary experience already shows that their behaviour when taking up or losing water is entirely different from that of the rigid gel. Anyone familiar with photography, for instance, knows that the gelatine film does not become opaque at any stage of the imbibition or drying process. Another difference is noticeable in the behaviour of gelatine in water and in water vapour; the amount of water taken up is not the same in both cases. Experiments on this point were made by Schroeder, who kept a gelatine plate, weighing dry 0·904 gramme, in air saturated with moisture for eight days, at the end of which it had taken up 0·37 gramme of water, the weight then remaining constant. The plate was then submerged in water at the same temperature and took up a further 5·63 grammes in one hour. If the gel is now placed into a dry atmosphere, it rapidly loses water at first—the speed of evaporation being at first almost as great as from a free water surface—then very slowly, until an equilibrium depending on the vapour tension is finally reached.

(To be continued.)

PERSONAL AND OTHER NOTES.

Proposals for the erection of another great museum, devoted to all branches of science, pure and applied, and geology, at South Kensington are contained in the second report, issued on Tuesday, June 4th, of a departmental committee, whose members include Sir Archibald Geikie and Sir William Ramsay.

Professor J. Norman Collie has been appointed Director of the Chemical Laboratories at University College, in succession to Sir William Ramsay, as from September 1st next.

No chemist's name appeared in the Honours List on the occasion of the celebration of the King's Birthday on June 14th, and scientific men generally were unrepresented except that Lieut.-Col. David Prain, F.R.S., Director of Kew Gardens, received the honour of Knighthood, and Dr. Andrew Balfour, of Gordon College, Khartoum, received the C.M.G.

Dr. F. V. Darbishire, B.A., formerly of Wye College, and a member of the British Sugar Beet Council, has been appointed Chemist to the Wendessen Beet Sugar Factory in Brunswick, Germany, for the season 1912–13.

Sixty-nine students have entered for the Institute of Chemistry's examination to be held this month. It is interesting to note from the register of Fellows, Associates, and Students, that at the present time 1,160 Fellows, and 224 Associates, making a total of 1,384 members of the Institute, are registered as members. In addition to this there are 337 registered students on the books of the Institute of Chemistry.

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER V.

APPLICATION OF CHEMICAL RESEARCH TO INDUSTRY.

> "He that will not apply new remedies must expect new evils. They that reverence too much old things are but a scorn to the new."—*Francis Bacon.*

THE effect of the development of chemical research in its application to industry is seen in the fact that the virtual control of certain industrial operations has passed to science. This is a characteristic feature of the age. It is hardly too much to claim that this condition must in time become a normal one. It is difficult to call to mind any manufacture which might not benefit from such a change; for the preparation of raw materials and every subsequent stage of manufacture may certainly be influenced by such means. This is so evident, that it only calls for passing notice.

In some cases this influence may be directly observed in the product itself, as in high speed steel, artificial indigo, etc. In others, where the changes are connected with the details of works, manipulation, and generally kept secret from the knowledge of rival operators, the influence is not so evident to the public eye.

Some idea as to the scope of modern chemical research in its relation to industry may be gathered from the following sectional headings adopted by the Society of Chemical Industry for abstracting purposes. General Plant, Machinery, Fuel, Gas; Mineral Oils; Waxes; Destructive Distillation; Heating, Lighting; Tar and Tar Products; Colouring Matters and Dyes; Fibres, Textiles, Cellulose, Paper; Bleaching, Dyeing, Printing, Finishing; Acids, Alkalis, Salts; Non-Metallic Elements; Glass, Ceramics; Building Materials; Metals, Metallurgy; Electro-Metallurgy; Electro-Chemistry; Fats, Oils, Waxes; Paints, Pigments, Varnishes, Resins; India-Rubber, Gutta-percha; Leather, Bone, Glue; Soils, Fertilisers; Sugars, Starches, Germs, Fermentation; Foods; Water Purification, Sanitation; Organic Products; Medicinal Substances, Essential Oils; Photographic Materials and Processes; Explosives, Matches. These divisions indicate the main branches of industry which already entail chemical research, and original investigation, in their development.

In addition to this direct influence on established industries, many new ones have been called into existence, as the result of chemical research in its widest sense. Some of these are already firmly established, and of great importance. The industry dealing with the fixation of atmospheric nitrogen bids fair to supply the world with cheap nitric acid, ammonia, nitrates and cyanides, urea, etc. The artificial silk industry has already supplied the markets with a cheap and efficient substitute for real silk. The artificial alizarine and indigo industries have reached a stage of fearless activity, and have profoundly modified the position of the corresponding natural products, having to an extent replaced them.

In all such cases the conditions of investigation and development are of an essentially different kind from those which are confined "*to constant speculation on the lines of a more rational theory*," but the general principles underlying the two branches of research are identical in their widest terms and conditions. The differences which exist are confined to detail, and are in many cases chiefly due to the relative scale of working.

An ideal training is certainly one which will enable the investigator to work in both pure, and applied chemistry; and this can evidently be best secured when it deals with the underlying principles, and practice, of research.

Utility of Industrial Research.—Financial advantage, and a correct solution to certain investigations, represents the ultimate aim of such research. The industrial advantage of a correct solution to these investigations must in some way be evident. The probable result of a successful issue may sometimes be estimated before the research is undertaken. Thus, the utility of a process for producing a reliable synthetic rubber at a cheap rate is self-evident. Such problems have therefore an interest to the capitalist. They are often considered from this definite standpoint by associations, individuals, or private firms.

Under modern conditions the success met with in many directions has been substantial. In the much advertised case of the aniline dye industry it has been found possible to establish laboratories in which a large staff of chemists are employed on research, from which important developments have resulted. Scientific investigation is in this, as in other cases, an essential factor to industrial success.

Connection between Theory and Practice.—An industrial application may follow naturally on an investigation which in its inception and characteristics is only of theoretical importance. The development of the Mond nickel process from the original investigation of carbonyls is a case in point. The systematic study of the general properties of colloids, and their reactions, is known to have exercised a profound influence on certain industries. Another example which might be mentioned is the influence of the metallographic study of alloys and metals on the metal industry generally: Auer von Welsbach's work on rare earths in connection with the incandescent mantle industry may also be cited.

The development of the Mond process to its present commanding position in the industrial extraction of nickel is known to have presented immense difficulties which were at one time looked upon as almost insuperable. Its successful manipulation on the large scale is one of the triumphs of chemical engineering.

The connection between investigation undertaken in connection with theory, and that of industrial investigation conducted on scientific lines is too evident to require further comment. The former occupies a definite and commanding position; the more so, as it has no immediate connection with direct gain of a financial nature.

The ultimate fusion of the relative interests of theory and practice, which must follow as a direct result of a closer relationship between the two sections, naturally leads to further developments. With this comes a further advance in the influence which science exercises over industry. Its influence in this direction is to-day self-evident. All that remains is to develop its latent-power to the greatest extent.

The present development of the gold industry of the Transvaal has to a great extent been possible through investigations conducted on the action of cyanides on metallic gold. Equally important developments in the textile industry have followed the study of the action of caustic soda on cellulose under varying conditions.

In both cases, however, the working out of detail was the important factor. The solubility of gold in cyanide solution, and the action of caustic soda on cotton were both known for years before any important practical application resulted. The extreme importance of an investigation being carried out scientifically, and to its possible limit, is thus demonstrated.

The object before the practical investigator (so far as the utilisation of the results of theory is concerned) is to reduce the period between discovery and its industrial application to a minimum.

The aim of the chemist is to achieve this in the shortest possible time, and secure the full advantage of such investigation. Many cases might be quoted where the direct influence of theory has alone given a clue to the solution of important problems in industry.

The general statement that all scientific knowledge will at some time be utilised, and have an influence on industrial development may be regarded as correct in its widest sense, especially when it is remembered that evidence of a negative character is sometimes almost as valuable as positive information. In industrial research it is often as useful to know what not to do, as the reverse.

It is obviously impossible to predict how soon knowledge may be usefully applied, and therefore any natural division between theoretical and industrial research should be reduced to its narrowest limit, and this condition may best be met by the practical investigator having a sound working knowledge of theory.

When such a problem has to be undertaken, this influence must be considered in all its possible bearings: this condition applies equally in the case of industrial investigation, as in that of further investigation in theory.

Scale of Working.—It is sometimes very difficult to decide the scale upon which the investigation shall be conducted. This is an important point and one which will largely depend upon possible aims, and developments which may be looked for. It is generally found that processes worked out in the laboratory, with a view to their ultimate use on an industrial scale, have to be subsequently modified in many details. In industrial research other conditions apply to those observed when working in a laboratory, where results are obtained which are complete in themselves. In the face of this condition, the past experience and working conditions of the investigator will probably determine the actual scale on which the research is conducted.

The industrial chemist must have some knowledge of the general conditions involved, when laboratory investigation has to be extended to practice on the larger scale. Subsequent difficulties may often be obviated by working under correct conditions in the laboratory in the first place; and it is here that practical experience plays such an important part.

The natural difficulties met with in this transition stage have been lessened in some cases by the establishment of experimental work, operating on an intermediate scale, which may be considered as the equivalent of full-scale conditions. In this way the ultimate cost of production and methods of procedure may be accurately ascertained.

Experimental works dealing with processes connected with the fixation of atmospheric nitrogen may be seen in Norway. A similar one exists at Spandau for the purpose of establishing the value of processes which have for their object the manufacture of the industrial scale of nitrogen products from cyanamide. Many other cases may be brought to mind of a similar nature.

Where the industrial position cannot be accurately estimated, this procedure is one which should be followed. Under modern conditions of manufacture, new reactions are generally dealt with on an intermediate scale, especially when the conditions are exceptional or novel in their nature. This course is always a safe one to follow under any circumstances, and is to be generally recommended.

(*To be continued.*)

A New Hand Photometer. (By W. J. DIBDIN.)—A convenient portable instrument for the determination of the light emitted in any direction by a lamp or any other source of light is described. It is designed to embrace (1) Maximum open scale readings, (2) Convenience and accuracy in comparing lights of different colour, (3) Reliability by reason of the facility with which its indications can be checked. The rays falling on a Leeson Star Disc as improved by the author, when the instrument is tilted at the desired angle at such a distance from the illuminant that they shall be normal to the disc, are measured against those emitted by an electric lamp.

NEW METHODS OF ANALYSIS.

By HARLEY F. KNIGHT, F.C.S.

A New Method for Detecting and Estimating Nickel and Cobalt.

THE usual gravimetric methods for the estimation of nickel are not as easy and certain in working as is convenient, and a really entirely fresh method should be very welcome to chemists, especially to those who are not in the habit of frequently determining these elements, and so are unfamiliar with the various little dodges that are so well known to those who constantly deal with these important metals.

The process depends upon the fact that in neutral or slightly alkaline solutions both nickel and cobalt are completely precipitated by a slight excess of dimethyl-gloxime; the beautiful crimson colour of the precipitate is characteristic of the salt of nickel or cobalt.

The method is applicable to the separation of nickel and zinc in German silver and other alloys.

The alloy, of which about 0·5 gram have been taken, is freed from tin, lead, copper and iron by the usual methods, and to the ammoniacal solution from the precipitation of the iron 5 grams of ammonium chloride are added and the solution just neutralised with hydrochloric acid and treated with 0·5 gram of dimethyl-gloxine dissolved in alcohol (0.5 gram being taken for every 0·1 gram of nickel present) and ammonia added drop by drop until just ammoniacal; the solution is then heated, keeping the temperature a little below the boiling point for about half an hour.

The precipitate is collected on a tared filter or preferably in a Gooch crucible, washed with hot water and dried at 105° C. and weighed.

$$C_8H_{14}O_{11}N_4Ni \times 0{\cdot}2031 = Ni.$$

or the precipitate may be filtered off on an ordinary filter, dried and ignited to oxide. $NiO \times 0{\cdot}786 = Ni.$

When time is not of much moment the former method of weighing is to be recommended, owing to the factor being so very much lower and thus compensationg for small errors in weighing.

Under these conditions zinc is not precipitated, and may be estimated in the usual manner after boiling the filtrate with 10 c.cm. of hydrochloric acid in order to decompose the excess of the glyoxime.

The writer has found the method to be a very sound one, and the only drawback is the reagent, which at present is somewhat costly (La Verne W. Spring. J. Ind. Eng., 1911, *3*, 255–256).

Estimation of Nitrates in Waters.

In dealing with the estimation of nitrates in waters, most of the text-books are, as usual, lamentably behindhand, and even methods that have been in use for many years are quite unknown to those who only have access to a few reference books and not to the current literature on the subject.

Few radicles have been treated in so many varied ways as that of N_2O_5, but for ordinary purposes it has been the practice of late years to use the phenol sulphuric acid process, one good enough in itself, but having the inherent disadvantage of requiring the reagent itself to be freshly prepared.

There are two methods which the writer has had experience with that both give satisfactory results, and are, moreover, simple to work, the second of which is slightly to be preferred on account of the rapidity with which the results may be obtained.

Method 1:—In this the phenol sulphuric acid is replaced by a 1% solution of salicylic acid in sulphuric acid, which may readily be prepared in a few moments.

From 10-50 c.cm. of the water to be tested is evaporated, with 1 c.c. of the salicylate solution to a low bulk on a water bath, until a thick syrup is obtained, this is then diluted with 10 c.c. of water, allowed to stand for a few moments and poured into a Nessler tube with 10 c.c. of ammonia or solution of caustic soda, and the depth of the yellow colour compared with that obtained by treating in a similar manner known quantities of potassium nitrate.

The presence of chlorides does not affect the results, and for the water supplied by most of the Water Boards it will be found that 10 c.c. are ample for a determination.

Method 2:—This process has many points of preference over the former, not the least of which is that it may by directly applied to any water without the preliminary concentration with the reagent, and further the blue colour which is produced is more easily matched than the yellow of the former method, and artificial light is just as good as daylight for the purpose.

The reagent used may be either diphenylamine or its hydrochloride, dissolved in pure concentrated sulphuric acid, a suitable strength being about 0·25%, or say 0·5 gram, in 100 c.cm. of acid.

If 1 c.cm. of the water under test is mixed in a Nessler tube with three drops of the reagent and 10 c.cm. of pure sulphuric acid added, a blue colour is produced in degree according to the amount of oxidised nitrogen present, and is compared with the colour obtained by using a standard solution of potassium nitrate containing 1–2 parts of N_2O_5 per 100,000.

The match test being made by taking 0·1–1 c.cm., making the fraction of 1 c.cm. up to 1 c.cm. with distilled water, and adding 10 c.cm. of sulphuric acid as before.

These two methods have both been given for the reason that the chemist frequently has to use the reagents that are at hand in the laboratory, and salicylic acid or a salicylate are usually to be met with in most laboratories, and, further, in cases where sulphuric acid, free from oxides of nitrogen, is difficult to obtain, then Method 1 is to be recommended as the amount used is only one-tenth of that used in the diphenylamine method.

Books Received.

"AN INTRODUCTION TO BRITISH CLAYS, SHALES AND SANDS," by Alfred B. Searle. Charles Griffin & Co., Ltd., London, 1912. Pages 451 + xi, including 10 Plates and 35 Figures. Price 7/6 net.

"GENERAL FOUNDRY PRACTICE," by Andrew McWilliam and Percy Longmuir. Second Edition. Charles Griffin & Co., Ltd., London, 1912. Pages 384 + iii, including Index. Chapters XXXVIII., including Numerous Illustrations. Price 15/- net.

"EXERCISES IN CHEMICAL CALCULATION," by H. F. Coward and W. H. Perkins. Edward Arnold, London, 1912. Pages 152 + v, including Index. Chapters XII. Price 2/6 net.

TESTS FOR MECHANICAL WOODPULP IN PAPER.[1]

By Eugen Merz and Hans Wrede.

Mechanical woodpulp and other lignified fibres, being a source of weakness in papers which are supposed to be resistant for a long period of time to the action of light, air, and other atmospheric effects, must be readily and conveniently detected and their presence should be quickly determined, both qualitatively and quantitatively. The known reactions of lignified fibres should serve as a protection for prints or manuscripts of valuable writings and prints that may not yellow speedily or prove easy of disintegration.

The difference in the cost of paper being so relatively slight as compared with the value of the printed or written records, it becomes the more important to decide the question, " Does the paper contain mechanical woodpulp, and, if so, how much ? "

The means and the different methods of testing lignified fibres will be critically considered in this article, and comparisons will be made with standard samples.

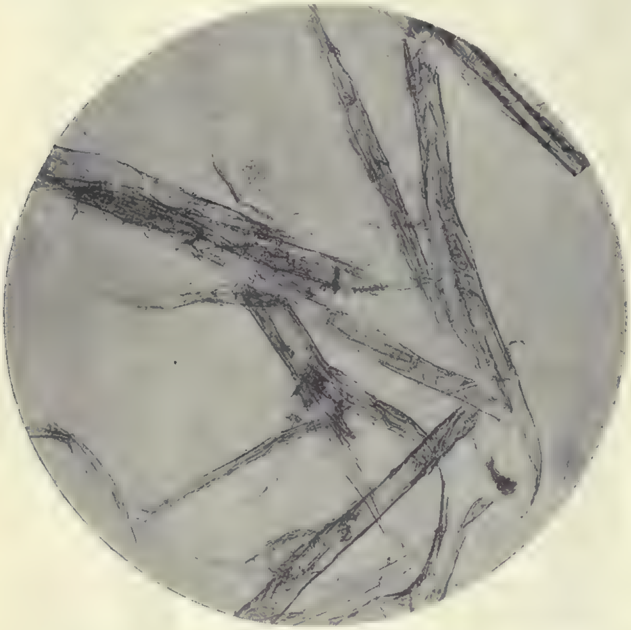


Fig. 1.—Photomicrograph of Mechanical Woodpulp (Spruce).

It should be understood that the test for the absence of mechanical woodpulp must not be considered as a measure of the quality of the paper, as some mechanical woodpulp is occasionally desirable in a paper to obtain special effects, as, for example, in the manufacture of different kinds of soft printing papers, coated papers or supercalendered papers, and where it is desirable to obtain opacity in light papers, so that the printing ink may not show through on the other side.

Mechanical woodpulp has a special affinity for aniline dyestuffs and has the property of taking basic colours. But in the case of valuable written or printed records in the form of documents or books, which must be preserved over a long period of time, mechanical woodpulp in any form is to be rejected. Papers containing mechanical woodpulp turn yellow when exposed to light ; the addition of this pulp generally weakens a paper and imparts to it a lower quality.

Several reactions for the detection of mechanical woodpulp are available, but only a few can be used as quantitative reactions by comparison with samples which are known to contain a definite amount of mechanical woodpulp. A solution of phloroglucin in hydrochloric acid colours mechanical woodpulp red, while aniline sulphate gives a yellow colouration, and dimethylparaphenylenediamine gives a red colour with a bluish tint.

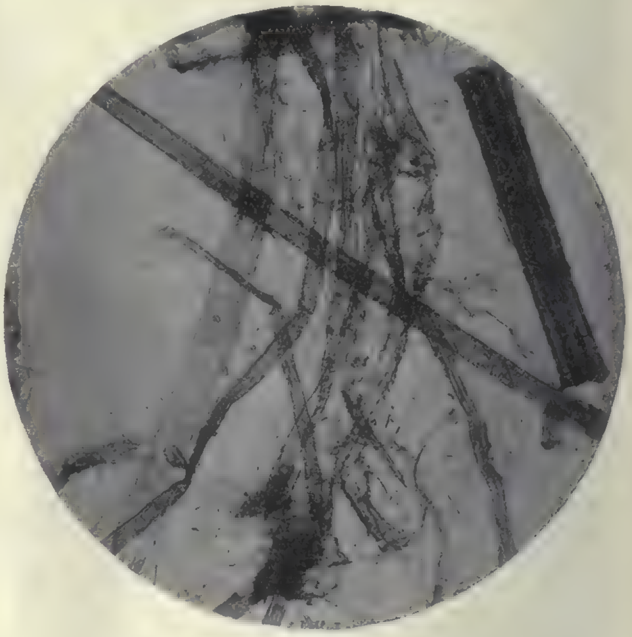


Fig. 2.—Brown Mechanical Woodpulp.

Colour Reactions in Absence of Mechanical Woodpulp.

Colour reactions are sometimes given with specimens of paper that are known to be free from mechanical woodpulp, and as trouble might be caused by an erroneous statement of composition owing to this, the reactions of some of the reagents used in testing paper may be cited.

Aniline colours of the yellow group develop a red colour in combination with hydrochloric acid, the red colour appearing instantly, while with solution of phloroglucin the colour develops more slowly until a permanent tint is produced. It is advisable, therefore, to always test the paper with a drop of hydrochloric acid as well.

When insufficiently boiled unbleached chemical woodpulp obtained by the sulphite process, and strawpulp, even when bleached white, often develop a reddish tint with phloroglucin, which would seem to point to the presence of lignified fibre ; but the tint differs from that obtained with a paper containing mechanical woodpulp, as the red tint, while uniformly distributed on the fibres, is only lightly developed. Portions of mechanical woodpulp may be detected in fibres scattered irregularly through the sheet.

It should be borne in mind that unbleached jute and Adansonia fibres both react distinctly to phloroglucin test solution, and these exceptions to the tests must be taken into consideration in analytical work. In special cases the microscope should be used in reaching a decision.

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[1] Reprinted from *Paper*, 21st Feb., 1912.

QUANTITATIVE TEST FOR MECHANICAL WOODPULP.

Various methods have been proposed for estimating the quantity of mechanical woodpulp contained in paper. These will be noted as they are described by Prof. Herzberg.

In 1882 Gaedicke proposed the use of mixtures of filter paper with 10, 20, 30 and 40%, respectively, of mechanical woodpulp made in the form of paper sheets for comparison with the samples to be tested.

In 1887 Dr. Wurster proposed the use of a paper saturated with dimethylparaphenylenediamine to be placed in a double sheet between the paper to be tested. After treatment with a few drops of water the resulting red colour is compared with a standard table of colour values. Both this so-called di-paper, the table and the descriptions, are now on the market; they are useful in revealing to a certain degree the amount of mechanical woodpulp contained in a given paper.

Dr. L. Gottstein colours the mechanical woodpulp with one of the reagents,[2] and under the microscope counts the coloured and uncoloured fibres, determining in this way the percentage of mechanical woodpulp present. This method is only of use where the amount of mechanical wood fibres present is exceedingly low.

The method of testing proposed by Dr. A. Müller, in which the paper is treated with cuprammonium solution, and the gold chloride method of Merz, Godeffroy and Coulon, were found impracticable in practice. The methoxy determination method of Benedikt and Bamberger with the Zeisel reaction is difficult to carry out and the results are not satisfactory.

After having determined that the paper contains mechanical woodpulp, by the use of one or other of the reagents mentioned, one of the standard samples is taken and placed in a flat dish, together with the paper under examination, when it is possible to determine by appearance within 10 or 15% of the amount. The sample is compared long enough to establish its identity with one of the standard colour specimens.

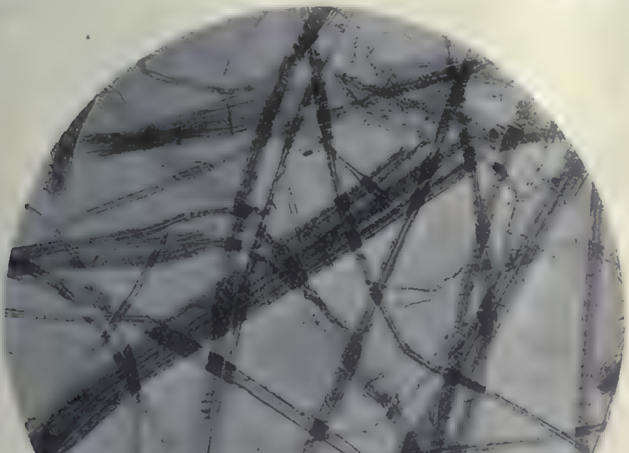

FIG. 3.—FIBRES OF UNBLEACHED JUTE (UNDER THE MICROSCOPE).

It is of importance to delay comparing the results for at least 10 minutes, as it takes this time for the strength of the colour to develop to the required intensity, where it is permanent and the result is definite.

The solution used is a 2% alcoholic solution of phloroglucin mixed with half its weight of concentrated hydrochloric acid. It is not practicable to mix these chemicals for a stock solution because, if mixed, the solution loses colour on standing and does not give exact results.

With this phloroglucin solution mechanical woodpulp turns a beautiful red colour, which shows instantly and grows in intensity to the deepest tint, according to the quantity of the mechanical woodpulp present, after 10 minutes of contact, when a tint is obtained permanent enough for comparison.

The other reagent used is a 10% solution of aniline sulphate acidified with a drop of sulphuric acid. This imparts a yellow tint to paper containing mechanical woodpulp.

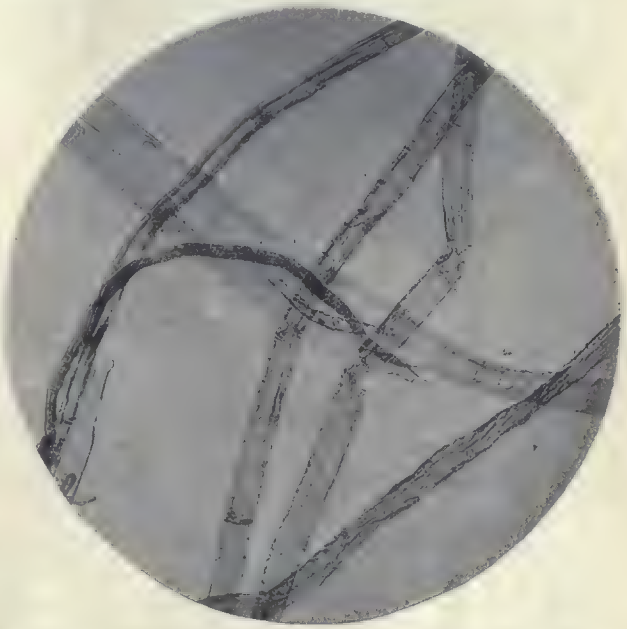

FIG. 4.—CHEMICAL WOODPULP (INSUFFICIENTLY COOKED).

Dimethylparaphenylenediamine, called "di-solution" by its original user, Dr. Würster, also reacts red with mechanical woodpulp, but the tint differs somewhat from the red colour obtained with phloroglucin.

The writer's method of applying the reagents is as follows: Into a flat dish pour two parts of a 2% alcoholic solution of phloroglucin and one part of hydrochloric acid (concentrated); compare the standard samples with the paper under examination until the same colour effect is observed, but for at least 10 minutes. Compare the colour in surface and look-through (perspection), the last on a glass plate. In order to compare the samples in look-through the weight or thickness of the samples should be identical, otherwise a new source of error will be introduced.

The same test may be applied practically with the aniline sulphate solution as well.

SOURCES OF ERROR TO BE AVOIDED.

First it must be carefully determined that the thickness of the paper corresponds with that of the standard samples, if the colour tables used in the trade are employed.

Allowance should also be made for fillers, especially for kaolin, which usually shows a lighter tint in the finished experiment. In a series of experiments made by Wrede with students at the papermaking school in Coethen, Germany, it was proved that an addition of 10 to 15% of kaolin gave only a light tint after 10 minutes. This might prove misleading and show less mechanical woodpulp in a paper than was actually present to the extent of 10%.

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[2] Phloroglucin in hydrochloric acid, aniline sulphate, or dimethylparaphenylenediamine.

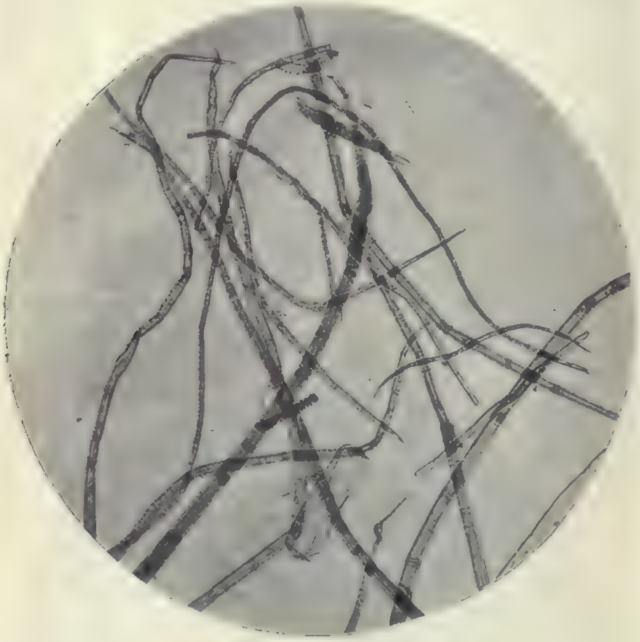

FIG. 5.—STRAWPULP (SOMETIMES LIGHT RED WITH PHLOROGLUCIN).

It was also observed in the Coethen paper laboratory that paper which contained kaolin turned much darker in the first few minutes, as compared with paper containing no filler. After standing for 10 minutes, however, the tint proved to be lighter than the standard sample.

Another factor to be considered is that mechanical woodpulp of pine wood (pine, spruce, etc.) colours much more intensely than the pulp of foliage trees. In doubtful cases it is important to examine the specimens under the microscope.

The Conversion of Starch into Dextrin by X-rays.—H. A. Colwell and S. Russ have recently shown before the Physical Society that when solutions of starch are irradiated for several hours by X-rays of moderate penetrating power, the opacity and viscosity of the solutions are markedly diminished. These physical changes are attended by chemical changes ; there is a partial conversion of the starch into soluble starch and dextrin. A quantitative estimation of the amount of dextrin formed after the starch solution had been irradiated for 8 hours showed that it corresponded to about 5% of the amount of starch initially present.

When solutions of dextrin were subjected to a similar exposure of X-rays, no conversion of this substance into glucose was obtained. From the fact that starch may be converted into dextrin by hydrolysis, a simple explanation of the effect would be afforded if water were decomposed by X-rays. From the negative results obtained by Kernbaum on these lines, however, it seems as if the effect were more likely attributable to a direct action upon the starch molecules, either by the X-rays or the secondary rays which they produce.

COMMERCIAL AND GENERAL NOTES.

Growing Practice of Essential Oil Adulteration.

A prominent German firm with branch houses in many parts of the world stated in a recently issued review of the trade in essential oils during last year, that the practice of adulteration is growing to an alarming degree. The interesting report contains the following reference to this subject :—

"We are compelled, to our regret, to record at this time the disagreeable fact that during last year the malpractice of adulteration had attained dimensions never before known in our industry. The alarming extent to which the ever-advancing scientific investigation of the constituents of the essential oils is being utilised by dishonest traders to practise cunning forms of adulteration, especially such as are designed to represent their goods as of better quality than they really are, is positively astonishing. In the great majority of cases the primary methods of examination, as, for instance, the determination of specific gravity, of solubility, and of vertical rotation, and even the simpler chemical tests, such as saponification and acetylation, no longer suffice to trace malpractice of this kind, and it is necessary to carry out the various investigations in all their complicated details in order to reveal the inferior nature of the artificial mixtures."

Soya Beans in Argentina.

Experiments with soya beans in Argentina during the past three years having proved very successful, leading farmers intend to devote themselves to growing the crop on a large scale in preference to linseed. As the percentage of oil in soya beans varies from 15·8 % to 23·2 %, inquiries are being instituted for seed beans having a high oil content, also for early and late varieties.

This forms only one of the various attempts of growers in different parts of the world to profit by the excellent demand existing for soya bean oil which is being utilised in growing quantities in preference to the more expensive seed oils.

The wide appreciation which our consumers of this product are showing has quite recently been clearly demonstrated by the rise in prices of soya bean oil in consequence of which it can no longer be regarded as a substitute for cotton oil. There is no doubt that the bean oil will gain even more importance in the future, and every attempt to increase our supplies deserves encouragement.

A New System for the Extraction of Animal Grease.

A new German system for the extraction of grease from animal offal is based on extraction by naphtha or some similar solvent. The material under treatment is placed in a closed digester, into which is pumped the solvent, previously vapourised and heated. As the gas comes into contact with the moist, cold surface of the offal some of it is condensed and filters down to the bottom of the vessel, taking with it a certain proportion of fat and moisture. This product is then passed to a distiller, where the solvent and the water are evaporated and sent to the condenser, while the fat or oil remains behind. This procedure is continued for eight to ten hours until the material is dry and free from grease.

It is stated that at Oldenburg, where the first plant of this kind was erected, the fat obtained is of a light-yellow colour, and is used by soap factories at Hamburg, while the residue finds a ready sale in the form of meat meal for feeding pigs and poultry. If desired, all but 1–1·5 % of the fat can be removed, but in practice it is found more economical as regards coal and solvent, to allow about 2·5 % to remain.

Dispensing of Radium Preparations in Austria.

By a recent Ministerial Decree the sale and dispensing of radium preparations has been regulated in the following manner: Radium works are allowed to supply radium preparations for bathing purposes if prescribed by a medical man. All other radium preparations for internal use can only be dispensed in pharmacies and on medical prescription. The dispensing, for internal use, of radium preparations containing barium is prohibited, and advertising any of them as medicaments for all kinds of diseases, either by circulars or labels, will also be punishable.

The Austrians evidently know the meaning of the proverb *gouverner, c'est prévoir*, and in framing these rules they prevent the exploitation of the preparations by unscrupulous persons.

A Japanese Fish-Oil Refinery.

The German Consul at Kobe reports the erection of a Japanese fish-oil refinery near Osaka. The concern has been partly financed by German capitalists and possesses a nominal capital of 1,000,000 yens, of which 400,000 yens are paid-up. The object of the "Teikoku Gyoya Seisei Kabushiki Kaisha" is the production of glycerine and fatty acids from fish-oil, according to a new German process. The factory is being built near the railway from Osaka to Kobe, and will soon be in operation. It is expected to deal with about 5,000 kg. of fish-oil per diem.

As glycerine is used in increasing quantities for industrial purposes the Osaka market offers good chances for the product of the new factory. The firm counts particularly on the sale of the glycerine to the State dynamite factory at Iwahana, which at present is buying all its glycerine abroad.

The fatty acids which will be produced, including palmitine, stearine and oleine, are to be sold to soap makers. Some of the larger Japanese soap factories have recently engaged German technical men in order to introduce economical and scientific methods. The great English firm of Lever Brothers, near Osaka, will not buy their fatty acids in Japan.

It is too early to speak of the possibility of making large profits by fish-oil refining, but the great difference in price between the raw product and the refined article seems to warrant the expectation of profitable working.

Protest against the German Spirit Monopoly.

A mass meeting of consumers of industrial alcohol has recently been held in Berlin for the purpose of discussing the proposed revision of the spirit duty which threatens to put further difficulties into the way of the consumers. Even under the present circumstances many users, particularly the manufacturer of artificial silk, are unable to face foreign competition in consequence of the high prices for industrial alcohol which raise their costs proportionately by 35-50% over those of foreign makers. Not only does this prevent them from competing on the world's market, but it even compels them to sell under cost on the home market. The same may be said of other branches of industry consuming great quantities of alcohol, such as celluloid manufacture and artificial leather making. The assembly passed a resolution to petition the Government for an amelioration of the position which might be brought about either by a reduction or removal of the import duty on foreign industrial alcohol or by permitting consumers to produce the alcohol required for use in their own works.

Synthetic Rubber.

The subject of synthetic rubber production is not only widely discussed at present in German scientific circles, but several large chemical firms are also engaged with experiments in this direction. Among these the Elberfeld Farbenfabriken and the Badische Anilin and Sodafabrik and the Aktien Ges. vorm Schering, Berlin, are carrying out experiments with the object of producing synthetic rubber from isoprene. Dr. Hofmann, who has charge of the researches now being conducted by the Bayer Company at Elberfeld, read a paper before the Society of German Chemists, in which he stated that he was induced to make experiments by reading a report of an English lecture on this subject several years ago. His first success, after much preparatory work, was the production of isoprene from cresol, and shortly afterwards he produced his first sample of artificial rubber. In his opinion, the whole question is nearing its solution, though he was not prepared to say how long it would require to make the synthetic product a competitor of the natural one.

Prof. W. H. Perkin has recently published the fact that Dr. F. H. Matthews in September, 1910, discovered that isoprene left in contact with sodium had turned into a solid mass of rubber. Also that Prof. Fernbach had worked out a fermentation process leading up to the production of isoprene.

Efforts to Revive India's Natural Indigo Industry.

The recent efforts to reinstate natural indigo in its former position of prominence as standard material for blue-dyeing have created quite a little stir in the principal markets of the world. It may be recalled that hardly ten years ago natural indigo was the one and only dye of importance for certain purposes. Its prominence was lost in the struggle with the synthetic product made in Germany. The rapid progress of that country's trade in artificial indigo is too well known to require entering into, and we merely mention that its manufacture has become one of the most profitable and flourishing branches of the chemical industry of the Fatherland. In order to rescue natural indigo from its present obscurity a movement has been started, which is being watched with interest by everyone connected with the industry. One of the most practical methods of carrying on the fight to restore the natural dye to its former status is the proposal to market it as a paste, instead of in the form of dry cake or powder, as has been the custom.

The convenience to the practical dyer of working with a paste is so great that, even if he could buy natural indigo cheaper than the synthetic product, he would prefer the latter, unless he could get the natural indigo in the same convenient form. This is explained by the trouble and expense of grinding the indigo into a fine paste.

Synthetic indigo has gained a strong foothold on the consumers in all parts of the world, and it would require a strong inducement to cause their return to the natural product, so that the struggle promises to be a keen one.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

25716/10. W. WYLD, Birmingham. **Distilling Ammoniacal Liquors.** 3 May, 1911.

The invention relates to the distillation of ammonia and other solutions, such as ammoniacal liquor of gas works, effected by spraying the liquor in a plurality of chambers. According to this invention, the distillation is carried on at different pressures in the respective chambers. (4 claims, 2 Figs.)

3247/11. N. TESTRUP, London. **Sewage Treatment.** 8 February, 1911.

The invention consists in a process of disposal for sewage or the like consisting in heating the sewage to such a temperature under pressure (130° C. or upwards) that it becomes readily filtrable, and in then separating the liquid from the solid matters by pressure filtration. (7 claims, 3 Figs.)

9272/11. C. W. JULIANS, Ponders End, and THE BRITISH STONE AND MARBLE CO., LTD., London. **Artificial Stone.** 13 April, 1911.

This invention relates to the manufacture of artificial stone in which the stone, slag or the like is crushed into a fine powder, mixed with burnt lime, slaked and subsequently pressed and carbonated. According to the invention, the mixture is obtained by mixing the burnt lime with a portion of the finely crushed stone or the like, then slaking the mixture with hot or cold water and, after the lime has completely slaked, adding the remainder of the stone or the like and rapidly mixing until it attains the consistency of cream prior to pressing without subsequent treatment with steam. (1 claim.)

9632/11. W. HIBY, Wakefield. **Gas Purification.** 20 April, 1911.

In the purification of gases produced by the carbonisation of coal, the naphthalene is removed by suddenly chilling the gases at a point of the purifying or recovery system where their temperature is near the dew point of naphthalene by means of an agent which is forcibly injected into the gases as a spray, so as at the same time to remove mechanically and continuously the naphthalene separated from the gases by chilling. (2 claims.)

10325/11. G. A. BRONDER, New York. **Illuminating Gas.** 28 April, 1911.

The invention relates to a process for generating a gas consisting of a mixture of coal gas and water gas, and consists in utilising the coke produced from a charge of coal to produce water gas, the entire quantity of which is mixed with the coal gas produced from the charge of coal, and in utilising the semi-water gas produced in the treatment of the coke to heat the coal gas retort or retorts. (4 claims, 3 Figs.)

10338/11. S. J. RALPH, Stockton-on-Tees, and SULPHATES LTD., Peterborough. **Copper Compounds.** 28 April, 1911.

A known treatment of liquors containing copper and iron in solution for the purpose of separating the iron consists in treating the liquor with an oxidising agent in the presence of a compound of copper, which is insoluble in the liquor but soluble in acids. According to this invention, the insoluble copper compound is produced in the liquor by adding barium carbonate, oxide, or hydrate to the liquor. (1 claim.)

14415/11. J. S. REMINGTON, Grange-over-Sands. **Treatment of Flour.** 17 June, 1911.

According to this invention, flour is treated by the addition thereto of meal obtained from a malted grain, preferably barley malt, the malted grain or the meal having been treated or mixed with phosphoric acid previous to its addition to the flour. (3 claims.)

19298/11. E. W. KUHN, Brussels. **Manufacture of Sterile Butter and Cream.** 29 August, 1911.

The improved process of manufacturing fresh sterile cream and butter consists in completely sterilising milk under pressure and at a temperature of 110° C. in a gyrator, bringing the sterilised milk into a metallic centrifugal skimmer, previously sterilising the pipe connection between the gyrator and skimmer and the latter, aseptically skimming the sterilised milk for obtaining absolutely sterile cream, sowing the sterile cream with pure lactic yeast, maturing the cream in filtered air, and churning aseptically the acidified cream in a room aerated with filtered air. (5 claims, 1 Fig.)

19973/11. C. V. THIERRY, Paris. **Zinc.** 7 September, 1911.

The invention consists, in the metallurgy of zinc, in charging an electric furnace with oxide of zinc and with carbon in such relative proportions that all, or practically all, of the charge is evolved by the resulting reaction in the form of fumes and gases. (5 claims.)

28872/11. J. L. LAWSON, Leith. **Flour Purification.** 21 December, 1911.

The method of purifying flour, grain, rice, and other substances in accordance with this invention consists in passing said substances under a series of electrodes which attract upwards and into themselves, either by the forces of attraction or attraction and repulsion, the branny particles and other impurities. (7 claims, 5 Figs.)

2806/12. SOUTHALL BROS. AND BARCLAY, LTD., and C. S. ROY, Birmingham. **Glycerophosphoric Acid.** 3 February, 1912.

The manufacture of pure monoglycerophosphoric acid is effected, according to this invention, by causing phosphoric acid to react on glycerine at a temperature between 100° C. and 105° C. under pressure of about 30 mm. (2 claims.)

11482/11. **Reclaiming Waste Rubber.** H. L. TERRY, G. SPENCER, and E. L. CURBISHLEY, Manchester. 12 May, 1911.

A process of reclaiming waste rubber by first comminuting it and then subjecting it to the action of a very strong solution of magnesium chloride, whilst heated in a jacketed pan or digester, from 212° F. to 400° F., preferably 320° F. to 330° F., and finally washing the material to remove the disintegrated canvas and adhering magnesium chloride prior to its being dried and sheeted. (2 claims.)

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" *Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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THE MANUFACTURER AND CHEMIST.

THE fact that the Institute of Chemistry recently called a Conference of its members to consider the question of public appointments, and also that the general question of remuneration offered by certain local authorities was discussed a few months ago, will be fresh in the memory of our readers.

It may, therefore, be opportune to refer once more to the corresponding question of the status of the technical chemist in this country.

The position of the industrial chemist has not been generally regarded as satisfactory in the past. It is, however, difficult to form an unbiassed judgment on this subject, and still more so to compare the position of the chemist in this country with that occupied by those working on the Continent and elsewhere. So many factors are involved in such an inquiry.

The technical chemist should always remember that his department must be judged on a commercial basis. Under modern conditions it should pay better than any other in the works. This is subject to the factor that in advanced research, and development on any scale, the chemist must in many cases be working some years in advance of actual practice. This is the point which the manufacturer does not always realise, but it is a condition of the contract of service. The chemist may be regarded as a middleman between the present and the future.

It may be stated in general terms that, in a large works, a competent research chemist, working under satisfactory conditions, should be able to ensure a benefit which, on a cash basis, may be estimated as equivalent to £5,000 per annum. This is what large industrial firms should expect. It is what the experienced research chemist should aim at.

Accepting this position as a standard, the question which chiefly concerns the manufacturer and chemist is—what proportion of this benefit shall discharge the obligation of the former to the latter? The position is obviously one which can only be satisfactorily settled on a business basis.

The preliminary training of a chemist to the standard set up by, say, the Institute of Chemistry or that of one of the leading Universities, is such that it compares with, even if it does not rival in complexity, that required for the Law, or Medicine.

In the absence of compulsory powers on the part of the Institute, it is possible for anyone to practise as a chemist in the industrial world, even if this condition may not apply to public appointments. It is, therefore, difficult to set up an universal standard of knowledge which will represent the minimum required by the chemist engaged in such work.

There is evidence that, where this knowledge and training is present, many British manufacturers are willing to deal on a proper basis with the young chemist. The fact that certain leading manufacturers are willing to engage students from a recognised university at an annual salary of £250 is a very substantial step in the right direction. It indicates that they are in real earnest, and there can be little doubt but that the chemist will fully respond to this situation.

It is a small matter to a firm, from the immediate point of view of assurance against the undue advance of its competitors, whether the young chemist is paid £100 or £250 per annum. It makes a great difference to the research chemist, or prospective chemical engineer who has to keep up the position of a professional man. What of the man with experience and knowledge who, after a training of the order specified, finds that he is actually conforming to the above standard of work?

He naturally expects a treatment as liberal as that of the service he is rendering. It is for the manufacturer to see that he stands for fair treatment, and that his scientific partner shall not suffer from the fact that his work is of a highly specialised order. Rather that the opposite may be the case. With a supply of chemists educated under the right conditions—and it may be regarded as a sign of grace that such an education can now be obtained in this country—the good sense of the British manufacturer may be trusted to see that the chemist receives the recognition he deserves.

Optics and Chemistry.

The recent Optical Convention has once more brought before the public, or that branch of it which specialises in Science, the urgent need for a standard in optical matters which can compare with that which rules on the Continent.

This matter is one which has a special interest to the chemist, for modern advance in glass-making has been developed along lines of chemical and physical research; and the use which the chemist makes of certain optical laws and instruments is too well realised to need more than passing reference.

It is, therefore, certain that the resulting formation of a permanent committee to deal with problems connected with the improvement of optical instruments will be welcomed by all interested in the development of this subject.

Professor Silvanus Thompson's address was, as might be expected, a very able *résumé* of past work. His remarks on the future of optical education in this country should receive the fullest consideration.

Some of these (as reported in *Nature*) have more than passing interest to the chemist.

> " To the optical industry as a whole the question of the scientific training of young men who shall hereafter become technical leaders and pioneers is a very serious one, in view of the stress of the times. Men are wanted who can undertake mathematical calculations with a first-hand practical knowledge how these calculations are applied in the design of instruments, and who have a thorough acquaintance with the whole range of optics. That training at present they cannot acquire at any of the universities. It is a melancholy fact that now, when this need is sorest, the pursuit of optics at our universities and colleges is in a deplorable state. Except in the Northampton Polytechnic, and one or two other institutes, the study of optics for its own sake is entirely ignored. Not one of the universities of Great Britain has created a chair of optics, though there are professorships and extensive laboratories for electrical engineering, for metallurgy, and for various branches of technical chemistry. In the universities and colleges the only people who are learning optics are merely taking it as a part of physics for the sake of passing examinations for a degree, and care nothing for the application of optics in the industry. They are being taught optics by men who are not opticians, who never ground a lens or calculated even an achromatic doublet, who never worked with an ophthalmoscope or measured a cylindrical lens.
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> " Again and again, as might be demonstrated by many instances, advances in optics have come about through the association of the highly trained mathematician with the practical workman, and most effectually when these are combined in one individual. But where is England to look for the training up of such men ? "

Professor Thompson gave an account of past attempts to interest the authorities in this important question, and recited the experience of those who have tried to put this matter on a proper basis.

> " For twenty-five years some of us have urged the need of an Institute of Technical Optics, where students of optics will be trained in optics by men whose work is optics. The need grows year by year. Deputations from the trade have waited on the London County Council, and questions have been asked in Parliament, yet in vain. It has been suggested that two separate schools are needed—one for optical workmen, the other for optical calculators, the latter to be a mere small department in one of the universities or colleges. Such a divorce of practice and theory would be futile. What is wanted is an establishment where the whole atmosphere is one of optical interest, where theory and practice go hand in hand, where the mathematician will himself grind lenses and measure their performance on the test bench, where brain-craft will be married to hand-craft, where precision, whether in computation or workmanship, will be a dominating ambition.
>
> " As yet the only attempt made towards this ideal is the optical department of the Northampton Polytechnic in Clerkenwell, where a handful of students are housed in wholly inadequate surroundings. In the future institute the teaching must be thorough and independent, and free from all ulterior domination of examinations. The examination blight, which has cramped education in so many ways, has brought us to this pass, that outside the centre just named there is not a college student in Great Britain who is being trained in *optics for its own sake*. The moral is obvious. The future optical institute must be properly housed and equipped as a self-contained monotechnic, concentrating all its energies on the one aim. On no consideration whatever ought it to be under the baneful influence of a university, where its students would be diverted from whole-hearted devotion to progress by the temptation of degree-hunting. Would that this convention might make it clear to those in authority that the optical industry is in deadly earnest in demanding the establishment of such a centre of optical training."

It is hardly necessary to state that all those connected with the experimental sciences will welcome any action which is being taken to put this extremely important section of scientific work on a satisfactory basis in this country.

The Royal Society.

Chemists will take particular interest in the recent celebrations of this Society. The number of chemists who have the right to place F.R.S. after their names has materially increased during recent years. This is as it should be, when the extreme importance of chemistry is remembered. In the early days of the Invisible College when " half imagination, half science " ruled as the order of the day, things did not run too smoothly with the Authorities. To-day the relationship between this Society and the Government is one of an advisory nature. The Government grant of £4,000 per annum which this Society administers in the interest of research seems to be almost extinguished in the light of present day requirements. Under modern conditions, this may be modified. The attitude of the Government, as expressed by the Prime Minister's statement, that direct financial aid is not to be encouraged, is one which it is difficult to appreciate. It must, however, be remembered that the grant to scientific colleges may, in a way, take the place of, or supplement, a more direct aid to research.

The Distribution of Fluorine in Animal and Vegetable Tissues, and its Estimation in Minute Quantities.

By G. W. Monier-Williams, B.A. (Oxon), Ph.D., F.I.C.

The presence of fluorine as a constituent of bones and teeth has long been recognised. Morichini, in 1803, found this element in the fossil bones of elephants, and two years later, in conjunction with Gay-Lussac, showed that it was also present in the bones of living animals. About the middle of the last century a considerable amount of work was done upon the subject, the results obtained being somewhat divergent, owing to the faultiness of many of the methods employed. More recent work by Carnot (*Comptes Rend.*, 1892, *114*, 1189; 1892, *115*, 243), Jodlbauer (*Zeitsch. fur Biologie*, 1903, *44*, 259), and Hempel and Scheffler (*Zeit. Anorg. Chem.*, 1899, *20*, 1), has shown that the amount of fluorine in the bones and teeth of different animals varies from 0·05 to 0·50%. No distinction can be drawn in this respect between herbivora and carnivora, while different animals of the same species frequently show considerable variations in the amount of fluorine in their bones. Carles found (*Comptes Rend.*, 1907, *144*, 437, 1240) that the shells of marine molluscs may contain as much as 0·012% of fluorine, while freshwater and terrestrial shells contain from 0·002 to 0·004%, and concluded that this element is far more widely distributed than was formerly supposed.

Numerous analyses of fossil bones have shown, almost without exception, a far greater percentage of fluorine than is found in the bones of living animals, and the relative age of the fossils is apparently a more important factor in this respect than the lithological character of the particular deposit in which they occur. An attempt has actually been made to draw conclusions as to the relative age of fossil bones from the amount of fluorine that they contain. It is evident that the cause of this high percentage of fluorine in fossils lies in the capacity of bone phosphate to take up fluorides from very weak solutions, and that the prolonged action of such solutions may result in a very large amount of this element being taken up. The mineral fluorapatite, which often consists almost entirely of calcium phosphate and fluoride, may possibly have been formed in an analogous manner.

The occurrence of fluorine as an apparently essential constituent of bones and teeth has naturally led many observers to suspect its presence in other animal tissues, and from the results obtained it would appear that this element is fairly widely distributed in the body, more especially in those tissues which contain a considerable amount of phosphorus. Tammann found, for instance (*Zeit. Physiol. Chem.*, 1888, *12*, 322), that the yolk of eggs contained considerably more fluorine than the white or the shell; according to his experiments, the yolk of one egg contains 0·0002 grm. of fluorine, and the other parts of the egg practically none. He also found 0·0014 grm. in a calf's brain, 0·0004 grm. in one litre of cow's milk, and a trace of the element in cow's blood. Other investigators have claimed to have obtained a weighable quantity of fluorine from human brains and to have detected it in ox blood and in milk. Zdarek (*Zeit. Physiol. Chem.*, 1910, *69*, 127) found from 0·002 to 0·015 grm. of fluorine per kgm. of dry substance in various human organs, the liver, kidneys, and pancreas containing the most. It is noteworthy that he found only 0·002 to 0·004 grm. per kgm. in the bones, which is far less than has been found by previous observers in the bones of animals.

It is apparent therefore that fluorine, although occurring principally in the bones and teeth, is by no means confined to these, and it is quite conceivable that this element may be of considerable physiological importance.

As yet very little information is available as to the chief sources of fluorine in the body. It is well known that many natural waters contain appreciable quantities, and it is probable that it is widely distributed in spring and river water. Sea water has been stated to contain as much as 0·012 grm. per litre, and still larger amounts are present in certain mineral waters. A great many plants have been found to contain traces of fluorine, the most important investigations in this field being those of Wilson in 1852, who found traces of the element in various grasses and other plants, and of Ost (*Berichte*, 1893, *26*, 151), who found as much as 0·1% in the ash of the leaves of various trees. Several chemists have stated that natural wines contain traces of fluorine, but from the analyses of nearly 200 samples of wines of different origin Vandam (*Ann. de Falsif.*, 1909, *2*, 160) concludes that it is not invariably present, being confined to the wines of certain localities (compare also Kickton and Behneke (*Zeit. Unters. Nahr. Genuss.*, 1910, *20*, 193).

Woodman and Talbot (*J. Amer. Chem. Soc.*, 1906, *28*, 1437, and 1907, *29*, 1362), using a special modification of the etching test, have stated that traces of fluorides are normally present in malt liquors in amount not exceeding 0·02 parts per 100,000.

The majority of investigators in this field appear to have made use of the etching test, but it is very doubtful whether this test is really capable of giving reliable results with such minute quantities of fluorine as are here in question. The complete removal of every trace of silica is essential, or the fluorine will be evolved as silicon tetrafluoride and not as hydrofluoric acid. The ash of vegetable or animal tissues probably contains the greater part of

* *

any fluorine that may be present in the form of insoluble fluorides, which must be brought into a soluble form by fusing with excess of sodium and potassium carbonates and silica. The silica is then removed by means of ammonium carbonate or ammoniacal zinc oxide, and from the resulting solution the fluorine is precipitated as calcium or barium fluoride together with sulphate, carbonate, or oxalate, which assists the precipitation.

The resulting precipitate is then either weighed (Zdarek, *loc. cit.*) or submitted to the etching test. If the amount of original ash was at all considerable, the volume of the final solution from which the precipitation of calcium fluoride takes place will be comparatively great, and when it is borne in mind that 100 c.c. of water and 100 c.c. of 1·5 N acetic acid dissolve respectively 0·0016 and 0·011 grm. of calcium fluoride, it is evident that some of the published results obtained by this method must be accepted with reserve, especially when fractions of a milligramme of fluorine are in question. Still more is this the case with barium fluoride, in which form several investigators have endeavoured to separate the fluorine, as according to Kohlrausch, 100 c.c. of water at 18° C. dissolve 0·16 grm. of the salt. Moreover, it is exceedingly difficult to obtain a precipitate absolutely free from traces of calcium phosphate and silica. Of course, if an etching on glass is actually obtained with the precipitate, this will point to the presence of fluorine, provided that it is proved that the reagents used are free from every trace of the element, and that the glass is not attacked in the smallest degree by sulphuric acid vapour. Some Jena glass flasks which I have used repeatedly for Neumann's "wet ashing" method with a mixture of sulphuric and nitric acids have developed a "matt" surface on the interior, and have apparently been attacked to a considerable extent by the acid. It would be better, no doubt, to use plates of pure quartz as recommended by Nicklés.

Two papers by Woodman and Talbot (*loc. cit.*) on the sensitiveness of the etching test, are of interest as showing that the temperature at which a definite etching can first be perceived affords an indication of the quantity of fluorine present; the smaller the amount of fluorine, the higher the temperature necessary to produce an effect on the glass. The authors claim to be able to detect and approximately to estimate extremely small amounts of fluorine, down to one part in 25,000,000 of the solution examined, but the fact that the fluorine is first precipitated from solution as barium fluoride, the solubility of which is apparently neglected, would appear to discount somewhat the value of their observations. Several other methods that have been largely used depend on the distillation of the ash with sulphuric acid and quartz powder, and the estimation of the SiH_4 evolved. This principle is utilised in the various modifications of the "hanging drop" test, in which the substance to be tested is heated with silica and concentrated sulphuric acid, and the vapours allowed to impinge upon a minute drop of water. A film of precipitated silica is left after evaporation of the water, if fluorine is present. The silicon tetrafluoride may be measured in the form of gas as in Hempel and Scheffler's well-known method, or in weighed absorption tubes (Fresenius), or by conversion on contact with water into hydrofluosilicic and silicic acids, either of which may then be estimated by appropriate methods (Penfield, Treadwell and Koch). These methods, however, break down when the quantity of fluorine is of the order of a milligramme or less, although Tammann in his experiments on animal tissues claims to have obtained exact results by distilling, and estimating the fluorine as potassium silicofluoride. It is possible that approximately quantitative results could be obtained by distilling off the SiF_4 in a current of dry air and leading it through a capillary tube dipping under water. From the extent and appearance of the white ring of silica formed in the tube a rough idea could be obtained of the amount of fluorine present. Tammann states that this test will indicate as little as 0·0001 grm. of fluorine, but it is questionable whether this will be the case when a large excess of other substances are present, since Hinrichsen has pointed out (*Berichte*, 1907, *40*, 1497) that on decomposing certain silicates of alumina with hydrofluoric and sulphuric acids, it is sometimes very difficult to remove every trace of fluorine even by prolonged heating. I have found that if 1—2 mgs. of a fluoride are mixed with silica and excess of sulphates and phosphates of lime, magnesia and alumina, the mixture heated with sulphuric acid in a current of dry air, and the hydrofluosilicic acid in the distillate estimated colorimetrically by means of a peroxidised titanium solution, the theoretical quantity of fluorine is hardly ever obtained.

A test which might be of service in this connection is that given by Hermann for the detection of colloidal silica (*Zeit. Anal. Chem.*, 1907, *46*, 318). It depends on the insolubility of cæsium silico-duodecitungstate, and it is stated that a definite crystalline precipitate is obtained from 10 c.c. of a solution containing 0·0002 grm. of silica.

A very valuable method of estimating fluorine has been given by Steiger (*J. Amer. Chem. Soc.*, 1908, *30*, 219). It depends upon the well-known fact that hydrofluoric acid has a bleaching effect upon the yellow colour of titanium solutions containing hydrogen peroxide, and is best carried out on a solution containing not more than 0·003 % of fluorine. Phosphoric acid and certain other substances must be absent, as they also cause a slight bleaching of the titanium solution. If it is proved to be possible, by any modification of Fresenius' method, to distil over completely traces of fluorine as silicon tetrafluoride, and to concentrate the distillate without loss of fluorine to a very small volume, the colorimetric method applied to the distillate should be capable of giving very exact indications even when the quantity of fluorine present does not exceed a few tenths or even hundredths of a milligramme. The intensity of the bleaching action appears to be the same, whether the fluorine is present as hydrofluosilicic or as hydrofluoric acid.

Dioxymaleic acid may with advantage be used in place of hydrogen peroxide, as Fenton has shown

(*Proc. Chem. Soc.*, 1908, *24*, 133) that this substance gives an intense reddish-brown colour with quadrivalent titanium compounds, which is at once destroyed by hydrofluoric acid. The reaction is far more delicate than the hydrogen peroxide test.

An interesting spectroscopic method has been proposed by Ville and Derrien (*Bull. Soc. Chim.* [iii.], 1906, *35*, 239) depending on the change in the absorption bands of methaemoglobin on addition of fluorine compounds, but the method does not appear to be well adapted to the detection of minute quantities. Another method, which is also unsuitable for very small quantities, is that of Starck (*Zeit. Anorg. Chem.*, 1911, *70*, 173), in which the fluorine is precipitated in the form of lead chlorofluoride, $PbClF$. This compound is insoluble in solutions of lead chloride, and possesses the advantage of a high molecular weight as compared with that of fluorine.

It is evident that a reliable method for the estimation of traces of fluorine is still a desideratum. The question derives more than ordinary importance from the fact that compounds of fluorine are often used as preservatives in foodstuffs, although the amount thus added is usually far in excess of that naturally present.

An analogous case is that of boric acid, which was found by Allen to exist in many fruits in quantities as great as 0·016 %.

It is necessary therefore to exercise caution in drawing conclusions from the presence of minute amounts of fluorine in foodstuffs until further and more reliable data are available as to the quantities which may naturally be present.

THE VOLATILITY OF METALS IN A VACUUM.

By PROFESSOR T. TURNER, M.SC., University of Birmingham.

IT has long been known that certain metals, such as mercury, arsenic, and zinc, are readily volatile at comparatively moderate temperatures. The majority of the metals were, however, generally regarded as "fixed," though Boyle regarded them as probably having atmospheres of their own. Later Roberts-Austen showed that true diffusion occurred with metals even below their temperature of fusion, and Rose proved that gold was readily volatile when heated in the fluid condition in a stream of gas. In quite recent years, however, our whole conception of the volatility of metals has been altered, more particularly by the work of Moissan and of Greenwood. By the application of the electric arc Moissan and his pupils succeeded in vaporising all the common metals, in distilling considerable quantities of certain metals which had hitherto been regarded as refractory, and also in distilling unchanged certain metallic alloys. No temperature measurements were made by Moissan, and the experiments were conducted at atmospheric pressure. By the use of the electric resistance furnace and the Wanner pyrometer H. C. Greenwood determined the boiling points of a number of metals under normal pressure, and also conducted some experiments on the influence of different gases and varying pressures on the boiling points (*Chem. News*, 1911, *104*, 31, 42). Ruff and Goecke have since employed an electric resistance vacuum furnace, and temperatures as high as 2,500° C. Under these conditions even carbon and lime can be volatilised readily (*Zeit. Angew. Chem.*, 1911, *24*, 1459).

These researches had established two important principles, namely, that all metals are volatile under suitable temperature and pressure; and, secondly, that the interval between the melting point and boiling point varies in a remarkable manner. Thus, to take only two examples, tin melts at about 230° and boils at 2,270°, giving an interval of about 2,040°, while manganese melts at about 1,475° and boils at 1,900°, giving an interval of only 425°. It thus follows that metals which have a low melting point are not necessarily readily volatile.

The distillation or separation of metals at the high temperatures above mentioned is of great theoretical importance, but for practical purposes the hope of any immediate useful application under such circumstances is remote. It was, however, observed in the metallurgical laboratory of the University of Birmingham, during some researches on the gases in brass, that zinc, which was quantitatively separated from copper by Moissan in the electric arc, could be equally well separated in a vacuum at a temperature of 1,100°. This experiment, in conjunction with similar observations on certain other alloys, appears to open up a wide field for experimental research, and possibly also for

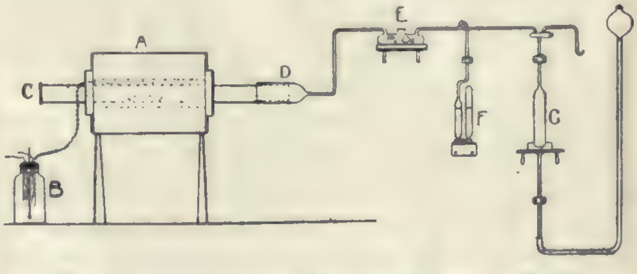


FIG. 1.—APPARATUS FOR HEATING ALLOYS IN VACUO.

A = Electric resistance furnace, with porcelain tube and boat.
B = Cold junction of thermo-couple.
C = Glass end plates with sealing-wax joint.
D = Glass reducing piece, with sealing-wax joint.
E – P_2O_5 drying tube.
F = Mercury pressure gauge.
G = Mercury pump, with three-way tap.

practical application. It has been found that certain metallic mixtures or alloys can be fractioned or separated at temperatures which range from about 450° to 1,200° C. Such temperatures are readily obtainable with ordinary coal or gas-fired furnaces, and gas-tight refractory materials can be obtained which readily stand up to 1,200°. For laboratory separations also, as with zinc from copper or German silver; lead from tin; or bismuth from copper, there would appear to be distinct possibilities.

The apparatus employed in the laboratory experiments is illustrated in Fig. 1, which is taken from the *Journal of the Institute of Metals*, 1912, *1.* 122.

The alloy to be examined is placed in a porcelain boat, or in a closed glass tube, according to the object of the experiment. It is heated in a porcelain tube in an electric furnace of the resistance type (A). The temperature of the tube furnace is observed by means of a thermo-couple, of which the cold junction is shown at B. At one end the porcelain tube is covered with a glass plate (C), which is sealed with sealing-wax, and which provides for the inspection of the sample during heating. At the other end a glass reducing piece (D), with a sealing-wax joint, connects the porcelain tube to the rest of the apparatus. A drying tube (E), containing P_2O_5, absorbs moisture, while the pressure is ascertained by means of a shortened mercury gauge (F). The apparatus is exhausted by the use of a simple form of mercury pump (G), which is provided at the top with a three-way tap. The gases drawn off from the apparatus may, if desired, be collected and examined. There are no rubber connections, and no grease is used, except a small quantity, of a special kind, for the three-way tap. By such an apparatus it is possible, in a few minutes, to obtain an exhaustion corresponding with a pressure of 1 mm. of mercury or less, and this does not appreciably alter during a period of 24 hours.

The rate of vaporisation is largely determined by the rate at which the vapour can be removed from the surface of the heated metal. The presence of a film of oxide greatly retards the evolution of gas, and hence, when working under ordinary pressures, the presence of a reducing atmosphere and of a light gas, such as hydrogen, facilitates the evaporation of the metal. When working under reduced pressure it is found that the rate of vaporisation is much retarded by the presence of even a small quantity of any gas. For example, the presence of coal gas at a pressure of only 20 mm. of mercury will very considerably retard the rate, as compared with what is obtained with 1 mm. or less.

So long as observations are confined to what may be regarded as ordinary furnace temperatures for the "non-ferrous" metals, or say between 400° to 1,200° C., alloys may be divided into five groups, as follows:—

Group I.—The metals forming the alloy are non-volatile at the temperature employed, and the composition of the alloy remains unchanged. This group includes the alloys of copper with tin, nickel, and aluminium.

Group II.—The volatile metal or metals are completely removed, and a quantitative separation results. To this group belong the alloys of copper with zinc, bismuth, and lead; also tin and lead; and zinc and iron, at suitable temperature.

Group III.—The metals form a non-volatile compound, but any excess of the volatile metal is removed. To this class belong the alloys of copper with antimony; zinc with cadmium; and zinc with magnesium.

Group IV.—A residue is left, which is of definite chemical composition, but not in simple atomic proportions. The arsenic-copper alloys afford an example of this class of alloys.

Group V.—The metals composing the alloy volatilise together, their relative proportions depending, in part, on the temperature employed. Of this group there are two subdivisions, viz.:—

(*a*) Those in which the alloy volatilises at a given temperature in definite atomic proportions.

(*b*) Those in which no such definite proportions are observed.

The experimental details upon which the above classification is founded have been published in a recent paper (Groves and Turner, *Journ. Chem. Soc.*, 1912, *101*, 585).

The result of this recent work on the volatility of metals has been to show that certain metals can be separated from each other by distillation in a vacuum with as much readiness and precision as a crude coal tar can be separated into its well-known constituents. Among the more evident directions in which practical separations on the large scale might be tried are the extraction of zinc from hard spelter, the refining of zinc-silver dross from the Parkes' process, the recovery of zinc from the gold-zinc residues of the cyanide process, and the concentration of tin in white metal scrap. It is only by practical tests on a fairly considerable scale that the commercial possibilities of such suggestions can be demonstrated. There may also be advantages in a method of separation at ordinary pressures by heating in a stream of a reducing gas. Whatever may be the details of the process or processes which may be ultimately adopted, there seems good reason to anticipate that sooner or later such methods of separation will find a definite place in metallurgical practice.

Pulp from Waste Flax Stalks.—For the production, according to a new process, of fibre from flax stalks, from which the seed (the linseed of commerce) has been removed, a company has recently been established by Argentinians in Buenos Aires, with a capital of 3,500,000 marks ($833,000). The fibres will be used principally in the manufacture of a fine, very durable parchment-like paper. Although the fibres are somewhat short, a German firm has obtained a patent on a process of spinning them.

It is asserted that already approximately 100 tons a month of these fibres are being produced by the process, and machinery has been ordered from Germany for the equipment of a new factory in Rosario, where it is hoped to produce 10,000 tons of fibre a year. Samples of pulp and of the paper made from it have been sent for exhibition to the Commercial Intelligence Branch of the Board of Trade in London, England.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE RELATION OF OXYDASES TO PIGMENT FORMATION IN PLANTS.

By E. Frankland Armstrong, Ph.D., D.Sc., F.C.G.I.

As differentiated by the microscope the colouring matters of plants are of two kinds, the soluble pigments in the cell sap and the insoluble coloured plastids distributed through the protoplasm. The chemist recognises a far wider variety, but knowledge on the subject is still very scanty owing to the difficulty of obtaining any quantity of the colouring matter in a pure state for analytical investigation. The more recent researches of Willstätter and others have taught that the plastids, which are usually yellow, orange and red, are probably hydrocarbons. The soluble pigments, for which botanists have adopted the general name anthocyanin, are mostly of unknown structure; the researches in particular of A. G. Perkin have elucidated the structure of numerous hydroxyflavone glucosides, and a few other pigments which are of technical importance as dyes have been studied.

Although so little is known of the structure of the red, purple, and blue colours of plants, a somewhat clearer conception has been formed of the manner in which they arise; it is this aspect of the subject with which it is now proposed to deal. It is considered, namely, that the formation of pigment is due to the action of an oxydase on a colourless chromogen. This chromogen does not normally exist in the cell sap as such, but it is present in the form of a glucoside. Under certain conditions in the metabolism of the plant the glucoside becomes hydrolysed by its appropriate enzyme of the emulsin type, and the chromogen, on liberation, is oxidised through the agency of an oxydase to form the soluble pigment.

This conception, which is somewhat novel in character (compare Wheldale, *Progressus Rei Botanicæ*, 1910, *3*, 457), requires examination in detail; it is of interest that it has originated more as the result of genetical investigations than from the chemical side, though what may be considered the final proof of the hypothesis has been afforded by chemical work.

The formation of colour, generally blacks and browns, in animal and vegetable tissue as the result of oxidation led to the discovery of the oxydases. These are usually regarded as enzymes and they fulfil the commonly accepted conceptions of enzymes in many respects, differing, however, in one important property, namely, they appear to be destroyed during the process of oxidation. The almost certain *rôle* of salts of metals such as iron or manganese in the process of oxidation is also not yet understood. On the other hand there is a steadily growing amount of evidence in favour of the essentially specific character of the oxydases, the property, which above all others, is characteristic of enzymes.

The modern view as to the nature of oxydases which we owe to Bach and Chodat regards them as consisting of a peroxydase together with an organic peroxide, which may be replaced by hydrogen peroxide. Very frequently the peroxide constituent is lacking from plant tissues and the oxydase is only made manifest after hydrogen peroxide has been added.

The process of oxidation of the colourless chromogen was at first thought to involve only the chromogen, atmospheric oxygen, and the oxydase, but recent work, more particularly that of Chodat (*Arch. Sci. Phys. Nat.* 1912, *33*, 70, 225), has made it probable that protein degradation products are concerned in the change even if they are not finally incorporated in the molecule of the pigment. Chodat selected *p*-cresol as his chromogen, tyrosinase as the oxydase, and allowed them to interact in the presence of the amino-acids singly and also of polypeptides, peptones, and other larger units of protein degradation, noting in each case the range of colour produced. Whereas *p*-cresol and tyrosinase alone produce a yellow colour changing finally to orange, in presence of glycine, a red colour is first formed changing to an intense cherry red, then to violet, and finally to a deep blue. The latter colours are only produced when the amino acid is present in sufficient proportion. In presence of the other amino acids which compose the protein molecule, a somewhat similar but exceedingly wide range of colour is produced. When the larger units of protein decomposition are present the change of colour stops short of the blue stage. In brief, the method allows of the production of a very wide range of colour, and when it is remembered that other phenols may be substituted for *p*-cresol the possibility of obtaining the natural colour range becomes apparent. The work of Chodat affords strong confirmation of the view that the natural pigments arise by oxidation; it also indicates a manner in which synthetic pigments may be obtained in sufficient quantity to investigate their chemical structure and properties. Such work may be expected to give more than a clue to the structure of the natural pigments.

The evidence for regarding the chromogen as present in the form of a glucoside is considerable. The view was first advanced by Palladin in connection with his work on respiratory chromogens. These he regarded as behaving in exactly the same way as we have already postulated for the anthyocyanin pigments, namely, the chromogens are cyclic substances present as glucosides, from which by the action of hydrolytic enzymes they are separated from the sugars, and then take up oxygen by the aid of the oxydases, thus becoming coloured. During the normal life of the plant the oxygen is given up again under the influence of reducing substances, but if anything occurs to upset the enzyme balance so that the interaction of the hydrolytic, oxidising and reducing enzymes is disturbed, the respiratory chromogens become evident by their colour. Such disturbing factors are mechanical injury, frost, or treatment with anæsthetics.

It is not easy for chemists and botanists to obtain quite the same conception of what is happening in the cell, but in any case it is agreed that normally, enzymes and the substances on which they act, are kept apart.

Recent work has shown that there are a variety of substances, which have been classed together under the term hormones, capable of penetrating the various layers composing the cell wall and setting up chemical interactions within the cell. Naturally the hormones vary considerably in the potency of their effect, but it is of very special interest and significance that the group includes a large number of the substances commonly found in plants in the form of glucosides. For example, benzaldehyde, phenols, acetone, which are widely distributed, to say nothing of hydrogen cyanide and the odoriferous principles, all act as hormones. The influence on the enzyme balance is thus far reaching; immediately a small proportion of glucoside has become hydrolysed the non-sugar constituent produced acts as a hormone, causing further liberation of active enzyme within the cell.

In this way the oxydase becomes set free to act upon the liberated chromogen. Experimental work carried out with the leaves of the *Aucuba* has carried this theory beyond the hypothetical stage (compare H. E. and E. F. Armstrong, *Proc. Roy. Soc.* 1910, *B. 82*, 588; 1911, *B. 84*, 226).

The co-ordination of hydrolytic and oxidising enzymes has also received application to account for the formation of the odoriferous principles of plants. Thus in the vanilla bean, coniferin is hydrolysed by emulsin to glucose and coniferyl alcohol, which is then oxidised by an oxydase into vanillin (*Lecomte Compt., Rend*, 1901, *133*, 745). Bourquelot has suggested that the fragrance of the meadow-sweet is caused by the combined action on salicin of emulsin and an oxydase, converting saligenin to salicylaldehyde (*Compt. Rend. Soc. Biol.* 1896, *48*, 314).

To establish more conclusively the part played by oxydases in pigment formation it is necessary to localise them in the plant and show that their distribution corresponds with that of the anthocyanin pigment. Until quite recently the technique of the identification of the oxydases left much to be desired, but new methods have rendered their localisation, both macro- and micro- chemically, a matter of ease (Keeble and Armstrong, *Proc. Roy. Soc.*, 1912).

By means of α-naphthol and other reagents it is possible to get a delicate mauve colour reaction with an oxydase present in the veins of flower petals and elsewhere. On the other hand, benzidine gives a brown coloration with the oxydase localised in the epidermal skin of plants as well as that in the veins. For the details of the method the original publication should be consulted; it is possible to introduce the reagent into the cell so that the reaction takes place *in situ* and to stop action before the colour formed has had time to diffuse into other tissues.

The flower selected for investigation was the Chinese primrose, of which a number of different-coloured varieties are known. It was shown conclusively that the distribution and intensity of the oxydase reaction coincide with that of the pigments.

More detailed allusion may be made to a specific problem of genetics of which chemical work has afforded very important confirmation. Both in animals and plants there are two types of white known, which, though indistinguishable among themselves, differ in their genetic behaviour.

The one type, known as *Recessive White*, when crossed with colour gives coloured offspring in the first generation and these, when crossed with themselves, give offspring in the proportion of three coloured to one white.

The other type, known as *Dominant White*, gives white offspring when mated with colour in the first generation, and three white to one coloured when these are self-fertilised in the second generation.

The explanation given by the breeders is that the recessive whites lack oxydase or chromogen or both, whereas in the dominant whites both oxydase and chromogen are present but they are accompanied by a factor which inhibits the oxidation.

The application of the methods of localising oxydase just described to this problem has afforded entire confirmation of the explanation stated.

The plant selected for study was again the Chinese primula, of which both forms of white flower are obtainable. The recessive white type was found to contain abundant oxydase and presumably to lack chromogen, since similar coloured flowers gave the same oxydase reaction all over the epidermal skin. With the dominant white flowers no oxydase reaction was obtained. It was found possible, however, to submit the flowers to a preliminary treatment and so remove the inhibitory substance: thus, after soaking the petals for some hours in a solution of carbon dioxide, a faint epidermal oxydase reaction could be obtained; after treatment with dilute hydrogen cyanide solution the inhibitor was so far removed that a strong oxydase reaction could be obtained all over the surface.

In this way it is demonstrated that dominant white flowers do contain an oxydase the action of which is ordinarily inhibited.

AGRICULTURAL CHEMISTRY.

Soil Humus.

By C. T. GIMINGHAM, F.I.C.,
University of Bristol.

THE term "humus" is unfortunately rather an indefinite one and from a chemical point of view is especially vague. We may perhaps define it as nearly as is possible, as that part of the organic matter of the soil which has undergone partial decay under the action of bacteria. Two processes of bacterial decay can be distinguished going forward together in the soil; the first, which requires abundance of air, results in the complete burning of all the carbon of the organic material to carbon dioxide, whilst the other, in more or less complete absence of air, gives rise to marsh gas or hydrogen, carbon dioxide and humus, the last gradually being further broken down. Evidently then it is under conditions of poor aeration that the greatest formation of humus takes place, *e.g.*, in pastures, heavy clays, and especially in water-logged soils, where in absence of lime a deposit of acid peaty humus is formed.

The actual chemical composition of humus compounds varies greatly, but they always contain more carbon and less hydrogen and oxygen than the material from which they are formed. They have invariably a dark brown or black colour, and much of the humus in normal soils is most probably present as "calcium humate." The humic acids are only very slightly soluble in water as such, but form more easily soluble dark-coloured salts with alkalis, so that they can be extracted from the soil, after treatment with acid, by means of ammonia or soda solution; humic acid can be precipitated from such solutions in the form of a dark flocculent mass by the addition of a mineral acid.

In addition to carbon, humus compounds always contain nitrogen and sometimes also phosphorus, and as they are gradually broken down to simpler compounds they serve as the source of food for the soil bacteria and thus finally for the growing plant. But apart from this direct influence on the fertility of the soil by keeping up the supply of plant food, the presence of humus has results of the utmost importance in determining the physical nature of all types of soils. This influence, which in all normal soils is uniformly favourable, is in great part due to the *colloidal* properties of humus compounds; and in a recent paper Thaer (*Jour. für Landwirtschaft*, 1911, 59, 9) discusses some of these effects. With regard to the permeability of the soil he finds that the humus colloids offer a greater resistance to the penetration of water than an equal amount of clay; but further experiments are wanted to clear up this question. The important influence of humus on the water-holding capacity of the soil is of course well known and has been many times demonstrated. This is due not only to the water being soaked up by the humus compounds, as though by a sponge, but also to the particles with their extensive surface surrounding themselves with a film of water, this film constituting a great part of the moisture that remains in an air-dry soil.

The property of increasing the water-holding capacity is naturally of special importance in sandy soils. Clay soils do not indeed stand so much in need of the action of humus in this respect, since the clay colloids act in the same direction; but humus none the less exerts a profound influence upon the fertility of heavy clay soils. It possesses a cementing action and thus brings about the formation of aggregates of the finest clay particles, with the result that the soil is rendered looser and more open and is better aerated. The same cementing action works in a contrary direction in sandy soils, serving to bind together the particles and so make the whole soil more coherent.

Further, the well-known absorptive power of soils for various materials is most in evidence in those which are rich in humus or clay, *i.e.*, in the soil constituents which have the largest surface and which function as colloids. This absorption is partly a chemical process due to interactions with zeolitic silicates, calcium carbonate and calcium humate (see *e.g.*, Hall and Gimingham: "The Interaction of Ammonium Salts and the Constituents of the Soil," *J.C.S.*, *91*, 677); but it is also in part a physical process dependent on the extent of surface of the humus and clay colloids.

In this connection, a publication by Baumann and Gully (*Mittl. der Kgl. Bayer. Moorkulturanstalt II.* Heft 4) is of much interest. As the result of their work on the humus acids of the Bavarian "Hochmoor" soils, they come to the conclusion that the hitherto accepted acid nature of these substances is solely a consequence of their colloidal condition and that the supposed salt formation has been confused with their powers of absorption. The authors maintain that the so-called humates are not bodies of constant composition and do not give the characteristic reactions of the ions of metallic salts, and believe them to be simply colloidal absorption-compounds. Among other points, they show that the weak solution of free "humic acid" which can be obtained does not conduct the electric current.

These views are strongly criticised by Rindell (*Internat. Mittl. für Bodenkunde I.*, 1911, 67), who insists that it follows from Baumann and Gully's conclusions that a colloid cannot possibly be an acid. He instances silicic acid and generally considers that the arguments put forward are by no means sufficient to establish the non-existence of acids in humus. He also points out that Robinson (*J. Amer. Chem. Soc.*, *33*, 564) and Schreiner and Shorey (*U.S. Bureau of Soils Bull.*, Nos. 53 and 74) and other workers have actually isolated various acids from soil humus. Tacke, also, in an account of the work of the Experiment Station of the *Zentralmoorkommission* in 1910, states that their investigations on the humic acids of moor soils do not confirm the conclusions obtained at the Bavarian Institute.

It is evident from the papers here noticed that attention is being more and more drawn to the important part played by colloids in the soil, and it is perhaps useful to refer to what seems to be a simple and good method for their estimation. König, Hasenbäumer and Hassler (*Landw. Versuchstat.*, 1911, 75, 377) suggest a colorimetric method based on the absorption of a dyestuff (methyl violet) by the colloid. The amount removed from solution by a given weight of soil appears to be directly proportional to the colloid content. If on further trial this method proves reliable, it should become of much value.

SOME CONSIDERATIONS REGARDING LATEX FORMATION.

By CLAYTON BEADLE and HENRY P. STEVENS, M.A., Ph.D., F.I.C.

THE yield of latex from *Hevea* trees uniformly planted is subject to wide fluctuations. This applies to individual trees, groups of trees, and individual trees at different periods. We have chosen the *Hevea* tree to illustrate the points we wish to bring forward, but no doubt the same considerations apply to other species. *Hevea* trees have been taken as we have more data and more accurate information in respect to this species.

At certain periods of the year, usually the months of February and March, the trees "winter." They show some individuality in this respect, as they do not all lose their leaves at the same time. Occasionally a tree will be found wintering at another time of the year altogether. To judge from the statistics published by rubber plantation companies, there is a considerable falling off in yields during these two months, but it is difficult to ascertain how far the falling off is due merely to the drier weather at that season of the year. In rubber-growing countries, such as Ceylon, where there is a distinct dry season in the first part of the year, it is customary on many estates to stop tapping during the months of February and March, or part of them, so that reports of most Ceylon companies show a distinct falling off during these two months as compared with January, and a distinct recovery again in April. In the Malay Peninsula there is no well-marked dry season, and the yields from estates, although showing some falling off after January, do not exhibit that regular decrease noted in the case of Ceylon estates, and in cases where the falling off in February and March is very appreciable the recovery in April is only a partial one. In many cases recovery does not take place till May. These conclusions are deduced from this year's outputs—last year was so exceptionally dry that all calculations were upset. It is not, however, so much to these yearly fluctuations that we wish to refer, but rather to the individual fluctuations and differences between individual trees. If you take a walk through any mature portion of a plantation which has been tapped an hour or two previously, and where, in consequence, the latex has ceased to flow, it will be noted that the amounts of latex collected in the cups varies very considerably and does not appear to be directly connected with the size of the tree. Some of the cups may be full to the brim, others are half empty or contain only sufficient to wet the bottoms or colour the water put into the cups. It will not probably be difficult to find trees that have yielded so little that the latex has remained on the paring surface and has not reached the cup at all, and instances may be found where there has been no response whatever to the paring and not a single drop of latex has exuded.

These differences are not due to any difference in the manner of tapping or skill with which the surface has been pared, for yields obtained from the tree one day will be usually repeated without any great change on the following day, and a tree which has not responded, or barely so, to the tapping knife will behave similarly on the next occasion. These remarks, however, apply only to tappings carried on at short intervals. If you take a walk through the same part of the plantation a few months later it may be found that the tree which was yielding prolifically is now yielding poorly, and *vice versâ*. If a tree does not respond it does not follow that it "contains no latex." If pricked on the opposite side it may or may not be found to yield latex. It therefore becomes very difficult to make any selection of trees and to distinguish between what are really the good and the poor milkers, and when it comes to seed selection or the cutting out of superfluous trees from closely planted areas it is probably best to rely on the apparent vigour and general appearance of the tree, particularly of the foliage, and the shade of green, which is regarded by many practical men as a good index of the rubber-yielding capacity of the tree. Theory can help us little in these matters, as we have so little experimental evidence to go upon. At the present time there is much difference of opinion as to the function of latex in rubber-yielding species, owing to lack of data. It may be (1) a reserve food, (2) an excretory product, (3) a water reserve, or (4) a protection against insects. In the latter case, the biting insect may be overwhelmed by the flow of latex. It is no protection to the tree against fungus growths, as the mycelium can penetrate between the latex vessels. The first three are the more important functions and have been upheld by different writers at different times. The latex may, of course, exercise different functions in different species or both functions (1) and (3). Looking at the subject broadly, there are two matters specially worthy of consideration. Firstly, as regards structure of the latex vessels and their origin. These differ in different species but may be separated into two classes. In the first class we have the systems found in *Hevea* and *Ceara* rubbers. Certain of the cells become differentiated from the remainder. Some authorities state that we cannot say beforehand of any particular cell whether or not it is destined eventually to develop into a latex cell or not. Those that become differentiated become connected up with one another by the breaking down of adjacent walls, and result in an anastomosing system. It is obvious that the connections between such cells will be frequently defective or incomplete. Not that parts of the system are entirely cut off from the rest, but that the cross walls in places will have been only partially absorbed, forming a series of cavities frequently with small inlets and outlets to the neighbouring cells. The irregular tubes so formed will offer considerable hindrance to the movements of a viscous fluid such as latex in its passage through the system.

Hence, in spite of considerable pressure, the severance of latex tubes, as in the process of tapping, will drain the latex from the immediately surrounding vessels only. After the latex has ceased to flow from the severed vessels the ends become blocked, and in the course of a few hours the pressure gradually fills the latex vessels, which consequently yield latex again on paring the cut surface of the cortex and opening the tubes. After paring the pressure begins to exert an effect and to fill the tubes once more. By pulling off the semi-dried layer of latex which has formed on the pared surface an hour or two after the flow has ceased there is sometimes sufficient pressure to cause a few drops of latex to exude.

Many latex-yielding trees, such as the *Castilloa elastica*, possess a system of a different type. The vessels are formed during growth by prolongation of the cells, and are not mere adaptations of already formed cells by the removal of adjoining walls. They form long branching regular-shaped tubes with smooth walls, which offer little resistance to the passage of the latex and, when severed, are drained for a much greater part of their length. Consequently, such trees yield an abundance of latex by a single tapping. The tubes once emptied take a long time to fill again, and it may not be practicable to tap the tree for another six months or more. The structure of the cell system would therefore appear sufficient to explain the yields obtained from different trees under different methods of tapping, the daily or alternate daily tapping in some cases and half-yearly tapping in others. It is evident that it takes the tree an appreciable time to manufacture the latex, which can be abstracted from the cortex by tapping, if large quantities be removed. Confining our attention to the *Hevea* tree, where we are on firmer experimental and statistical ground, it is found that, as might be expected, there is a limit to the amount of latex, or rather latex constituents, caoutchouc, etc., which can be extracted from a tree. Occasionally the effect of overtapping is to make the tree "run dry"—it yields no latex. In other cases the latex gets thinner, that is to say, it contains more water and less caoutchouc. If the tapping be too severe the situation, climatic conditions, etc., will largely determine whether the tree runs dry or yields thinner latex. In any case, the tree can only manufacture a certain amount of latex constituents, and if these are drawn upon too rapidly, diminished yields must result. Details cannot be given here, but the total solids may easily drop from over 40% to 10% or less. On the other hand, too much attention must not be paid to cases of so-called abnormal latex which have been published in text-books. The addition of water to latex, either in the cups or elsewhere, is so common a practice and so difficult to prevent that little attention need be paid to analysis unless the author has collected or supervised the collection of the latex himself. The amount of latex manufactured by the tree in a twelvemonth is very considerable. Three to four lbs. of solids per tree per annum are frequently obtained when averaging over large areas with trees four to eight years old. The whole of this material has exuded from, say, a one-quarter section of the cortex of the trunk from the base to a height of 5 ft. from the ground. Taking the average girth of the trees as, say, 24 ins., we have a yield of 4 lbs. of solids from an area of 2½ sq. ft. This is the area over which the cortex has been removed. The calculation is a rough one, but is probably not far from the mark. Yields per tree over large areas have been given by the companies cultivating those areas at 6 lbs. and over per tree per annum—such yields may have been due to rather heavy tapping. We have collected the following figures from the reports of well-known companies having a fair proportion of both young and old trees, and relating to the year 1909, as follows:—3·08; 5·35; 5·08; 5·46; 6·69; 4·69; 2·33; 3·59; 3·77; 3·15; 3·00; 1·25; and 3·96, giving an average of 3·95 lbs. per tree per annum. The variation in the yields are partly due to differences in the severity of tapping and partly due to the proportion of young and old trees. In illustration of this we may take the figure given by one well-known company for the years 1907 to 1911 inclusive.

(*To be continued.*)

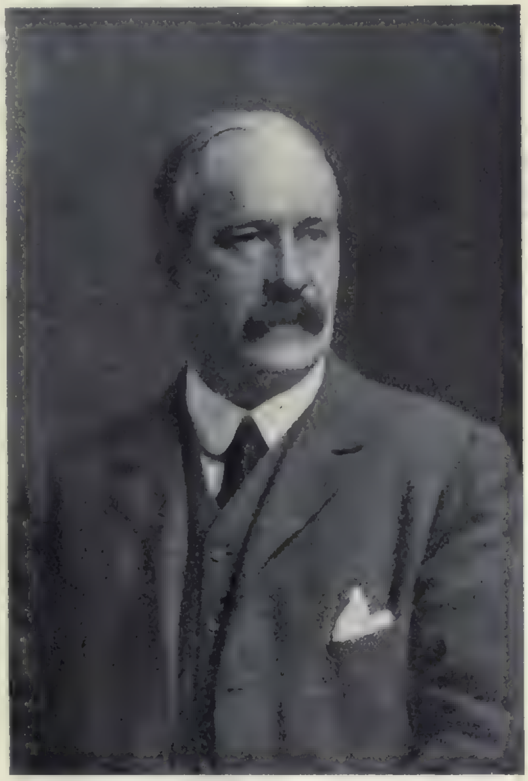
THE GOVERNMENT LABORATORY, LONDON.

By Chas. Simmonds, B.Sc., Analyst in the Laboratory.

The department of the Government Chemist comprises two branches—the main building at Clement's Inn, devoted both to general and to revenue work, and a smaller establishment at the Customs House, concerned with revenue matters only. In addition, there are a number of "chemical stations" for routine testing operations at various ports and other places in the United Kingdom, the organisation and working of which are supervised by the chief laboratory.

The main department has developed from a small chemical establishment, instituted at Somerset House in the year 1843 for the purpose of suppressing the adulteration of tobacco. Its staff at first consisted of one official only, Mr George Phillips, a gentleman who had made a special study of the chemistry and microscopy of tobacco, and who thenceforward guided the destinies of his little department for more than thirty years. That the guidance was able, and that Mr. Phillips possessed both scientific acumen and business aptitude, is the impression left on the mind by perusal of the official records, and strengthened on noting the subsequent progress of the laboratory.

It was not long before other duties besides the examination of tobacco were assigned to the new establishment. Thus in 1846–7 the staff, now increased to two, carried out an investigation into the comparative values of barley, malt, sugar and molasses to the distiller and brewer; and they subsequently worked out the method of determining the "original gravity" of malt liquors which, with but slight modification, is still in use both here and abroad. Perhaps it may not be out of place to recall the fact that industrial chemistry generally is under a debt of gratitude to Mr. Phillips, as it was he who suggested the "denaturing" of ethyl alcohol with wood naphtha (crude methyl alcohol) in order that such alcohol might be used free of duty in manufactures. No better general denaturant has yet been found—though for certain special purposes others are used. As potable alcohol is in most countries heavily taxed the matter is important. An idea of the magnitude of the interests involved may be gathered from the statement that nearly three millions of gallons of industrial alcohol per annum are used for various manufactures in this country alone. In addition, more than one and a half millions of gallons of the ordinary methylated spirit of commerce are employed, partly for manufacturing and partly for burning and cleansing purposes.



J. J. Dobbie, Esq., LL.D., D.Sc., F.R.S., Principal of Government Laboratory.

As a passing tribute to this bygone generation of revenue chemists one remark may be allowed. Some of the matters they dealt with being of very considerable importance both fiscally and commercially, independent reports upon their investigations were obtained from the leading chemists of the day—Professors Fownes, Graham, Hofmann and Redwood—who confirmed the accuracy of the original observations and conclusions.

In 1874 the late Dr. Jas. Bell, C.B., F.R.S., succeeded Mr. Phillips as head of the department, and remained in that capacity for twenty years. Genial and shrewd, with a flavour of old-world courtesy in his bearing, Dr. Bell was a capable administrator, and under his *régime* the laboratory continued to develop. From time to time analytical work for various state departments had gravitated to the Somerset House laboratory, and early in Dr. Bell's tenure this centripetal tendency was accentuated. Perhaps the most noteworthy instance was the appointment of the laboratory officials by the Sale of Food and Drugs Act, 1875, as referee analysts in cases of dispute concerning samples examined under the provisions of that Act. In fact, even at that early period, the department was in process of becoming a general state laboratory rather than a purely revenue establishment.

With the selection in 1894 of Dr. (now Sir Edward) Thorpe to succeed Dr. Bell as principal chemist, another step in the same direction was taken. For many years a chemical establishment had been maintained at the Customs House, and hitherto the two laboratories had been quite separate organisations controlled by the respective revenue boards. The new head was appointed chief of both branches, now together designated as the Government Laboratory, and was responsible directly to the Treasury. He was also named as the "Chief Chemist" to the Board of Agriculture for the purposes of the Fertilizers and Feeding Stuffs Act, 1893, in connection with the analysis of disputed samples. Moreover, the new principal, who had already made a reputation as a writer and lecturer on chemistry, was soon recognised in official circles as an energetic administrator and perspicacious man of affairs; wherefore his services were quickly utilised in various departmental enquiries. Such, for instance, were the Steel Rails Committee, appointed in 1897 as the result of the St. Neots railway accident; the departmental committee on the use of preservatives and colouring matters in foodstuffs, 1899—1901; and other committees or commissions which were appointed to enquire into the use of lead compounds in pottery, the efficacy of sheep dipping, the adulteration of butter, the use of industrial alcohol, and the question of arsenical poisoning.

All this meant further experimental work to be carried out by the laboratory. It meant also that the quarters at Somerset House soon became too small for the staff. Increased hitherto as the occasion required by the inclusion of adjoining rooms, they were now becoming congested, and in any case were ill-adapted structurally for the purposes of a large laboratory. Happily, however, at this juncture the clerical staff at Somerset House wanted more space, and Dr. Thorpe took the opportunity of obtaining the consent of the authorities to the erection of the present laboratory at Clement's Inn Passage.

To this the staff removed in 1897. Externally the laboratory is an unpretentious building; but it is well-designed, with good lighting and ventilation, and is provided with steam, refrigerating plant, and electricity, in addition to the ordinary laboratory appointments. Already, however, the cry is for more room! The illustrations show (1) the distillation room in the revenue division at Clement's Inn Passage; (2) one of the rooms in the Crown contracts division; (3) muffle furnaces and incinerating apparatus used in examining tobacco; and (4) one of the rooms used for examining various imported articles at the Customs House Laboratory.

Distillation Room in the Revenue Division.

At the present time most of the large Government departments—Admiralty, Board of Agriculture and Fisheries, Board of Trade, Home Office, India Office, Post Office, Stationery Office, War Department, and so on, utilise the services of the laboratory for some or all of their general chemical requirements, and a considerable proportion of the staff at the Clement's Inn branch is employed in carrying out analyses and examinations of articles submitted by these departments. It was therefore only fitting that not long after the appointment of the present principal, Dr. J. J. Dobbie, F.R.S., who succeeded Sir Edward Thorpe in 1909, the laboratory was constituted an independent department under the Treasury. This arrangement, which places all the executive branches of the Government on the same footing as regards the use of the laboratory, took effect in 1911, and the establishment is now officially designated as the department of the Government Chemist.

MUFFLE FURNACES AND OTHER INCINERATING APPARATUS IN THE TOBACCO DIVISION.

For many years the staff of the laboratory was recruited solely from members of the revenue services. It was justly considered that a knowledge of official procedure, and of the practical working of breweries, distilleries, tobacco factories and other industries concerned with dutiable articles, would be of great value to the future analyst when dealing with such articles. Not only so, but it would also be valuable when, as in the course of time would often happen, he was called upon to advise the authorities on points of administrative policy or legislative action with regard to the commodities in question. Hence any person wishing to enter the laboratory was required first to pass a year or more in gaining this preliminary experience. Admission was obtained by a competitive examination in elementary chemistry, physics and mathematics. The successful students then attended a course of lectures at the Royal School of Mines (subsequently the Royal College of Science).

With the growing proportion of general as distinct from fiscal work, the advantages of the original system have relatively diminished. Other arrangements, therefore, have now been adopted. The permanent chemical staff is recruited directly by Civil Service examination—limited, however, to candidates nominated by the Government Chemist. As these candidates may

ONE OF THE ROOMS USED FOR EXAMINING VARIOUS IMPORTED ARTICLES AT THE CUSTOM HOUSE LABORATORY.

include both those with and those without experience in a revenue department, it is possible still to retain the advantages indicated for the matters where they may be most needed. The assistant staff engaged in general work is selected from applicants who produce satisfactory evidence of suitable training; whilst revenue assistants are now employed as a rule only in the examination of dutiable articles and samples connected with them.

Coming now to the present organisation and duties of the laboratory, the permanent chemical staff consists of the principal, whose official designation is the Government Chemist, one deputy principal and twenty-six analysts, of whom four are "superintending" analysts. The number of temporary chemical assistants is seventy-four; and in addition some sixteen clerks are employed on clerical and secretarial duties.

Practically every kind of ordinary analytical work is done. At the Clement's Inn Laboratory there are three main divisions: (1) Agriculture, food and drugs; (2) Crown contracts; and (3) Revenue; the last being subdivided into branches dealing with (*a*) alcoholic beverages and tinctures; (*b*) tobacco; and (*c*) other revenue matters, including patent medicines, various licensing questions, and the use of alcohol for manufacturing purposes. Dairy produce forms the bulk of the samples analysed in the first-named division; it is examined at the instance of the Board of Agriculture and Fisheries, for whom also many questions of an advisory character are answered and experimental enquiries undertaken. Sheep dips, fungicides, fertilisers, feeding stuffs, and various other substances connected with agriculture are also analysed in this branch, which in addition is entrusted with the examination of samples referred by magistrates for special analysis under the provisions of the Sale of Food and Drugs Act.

ONE OF THE ROOMS IN THE CROWN CONTRACTS DIVISION.

In the "Crown contracts" division specimens of articles tendered to and purchased by the various Government departments are examined, and investigations made upon any questions respecting which the departments require chemical information and advice. The range of subjects dealt with is a wide one, covering the whole domain of ordinary analytical and consulting chemistry. Thus, to mention only a few matters as illustrations, it may be a question of a water supply, or of defective ventilation, or of protecting workpeople in dangerous trades, or of the best kind of ink for special printing, or of the drafting of a specification for rubber goods, and so on.

In the Revenue division the work is concerned chiefly with the fermentation, distillation, and tobacco-manufacturing industries. It includes such analyses and examinations as are required in the assessment of duties and rebates, and in the analytical control over the production, use, and sale of dutiable commodities. These are themselves relatively few in number—chiefly alcoholic liquors, tobacco, sugar, saccharine, tea, coffee and cocoa; but a large number of other articles have to be examined in connection with them, and the chemical questions involved are often by no means simple. In the Customs branch the work is almost exclusively confined to imports and exports.

The total number of samples dealt with last year (1910 — 1911) in the two branches was 186,044. The yearly total has been a constantly increasing one; in 1905 it was 138,508, and in 1900 it was 103,584.

From the ideal laboratory, no doubt, there will come a steady stream of research work. Of original investigation on the matters within its special purview the Government Laboratory throughout its career has generally managed to do a certain amount, perhaps as much as has been practicable in the circumstances. One or two of the earliest investigations have already been mentioned. Glancing down the records of subsequent years one notes investigations upon a number of matters, the results of which being required for departmental purposes only, there was no necessity to publish. Such, for example, were studies of the histology of certain plants, researches upon the chemical constituents of tobacco, on various problems connected with alcohol, and on the chemistry of ink and lard. Then in the earlier days of Dr. Bell's *régime* some useful studies of various foodstuffs were made in view of the new obligations incurred under the sale of Food and Drugs Act. Later an enquiry was made into the chemical changes involved in the souring of milk, so far as these affect the analytical examination of the soured product. This question was further examined at the instance of Dr. Thorpe, during whose tenure also various investigations were carried out in connection with public enquiries.

THE ELECTRICAL THEORY OF DYEING.

By WM. HARRISON, M.Sc.Tech.

THE "electrical" theory of dyeing was first proposed in 1904, by Perrin, in a paper on "Electrification by Contact" (*Journ. de Chim. Phys.*, 1904, 648 and 1905, 100) in the following words :—

> "Sans préciser d'avantage, nous dirons que ces teintures ont plus de chance de réussir si la charge electrique des granules du colloide est de sign contraire à celui de la grand paroi qu' on veut teindre."[1]

In 1905, V. Henri and Larguier des Bancels (*C. R. Soc. de Biologie*, 1905, 59, 132) carried out experiments on the dyeing of gelatine and used the electrical theory to explain the results.

In the same year Linder and Picton published a paper on "Solution and Pseudo Solution" (*J. C. S.*, 1905, 1931—1935), in which they considered dyeing as a phase of colloidal coagulation and described substantive dyeing as taking place in two stages, both of which were electrical processes.

In 1906, Bayliss (*Bioch. Journ.*, 1906, *1*, 172, 232) carried out some experiments in dyeing with direct and basic colours, and concluded that dyeing took place in one process, of electrical character.

In 1908, Larguier des Bancels (*Rev. Gen. Mat. Col.*, 1908, 193) showed that the mordanting of fibres occurred in a similar manner to the electrical coagulation of colloids.

In the same year Pelet Jolivet (*Rev. Gen. Mat. Col.* 1908, 97) showed how the problems of dyeing could be explained by the electrical theory.

In 1909 (*Rev. Gen. Mat. Col.*, 1909, 68, 257) the same author published papers in which the parallelisms between the laws of dyeing, colloidal coagulation, capillary ascension in absorbent materials and contact electricity were tabulated.

In the same year Larguier des Bancels (*Comp. Rend.*, 1909, 316—319) determined the electrical contact charge of fibres and found that wool, silk, and cotton took a negative charge in pure water. This negative charge was found to be increased by the addition of alkalies but decreased by the addition of salts and acids, and in the latter case the charge was sometimes reversed, particularly with wool and silk.

Schwalbe (*Die Chemie der Cellulose*, 1910, 127, 128) does not consider the electrical theory to be applicable in the case of direct colours on cotton, or that it offers any explanation of the fixation of the dye.

Gee and the author (*Trans. Faraday Soc.*, April, 1910) in carrying out electrical measurements confirmed the results of Larguier des Bancels and Pelet Jolivet, and further showed that fibres had a maximum negative contact charge at about 40° C., and this was used to explain the results of Brown (*Journ. Soc. Dyers and Cols.*, 1910, 92), who showed that wool took up more basic colour at about 40° than at other temperatures.

Last year the author (*Journ. Soc. Dyers and Cols.*, 1911, 279) showed that the electrical theory also applied to direct colours on cotton and to questions on fastness of dyed colours. The methods and apparatus used are described in that paper. The agreement between the electrical and dyeing results with cotton will be seen below.

With N/1000 solutions of various substances, the contact difference against cotton decreased in the order, sodium hydrate, Diamine Blue 2B, trisodium phosphate, Croceine Scarlet 3BX, sodium sulphate, magnesium sulphate, hydrochloric acid, aluminium sulphate.

With solutions of sodium hydrate, the contact difference increased with increase in the concentration up to N/1000, but decreased on increasing the concentration further.

With the dyestuffs the usual result of decreasing or destroying the contact charge is to cause precipitation or "salting out."

Thus, on adding aluminium sulphate to Diamine Blue 2B, at N/220 the contact charge was destroyed and the dye completely precipitated; further additions reversed the contact charge of the dyestuff, which again formed a solution (colloidal).

The order in which substances salted out Crystal Scarlet 6R more readily was :—sodium hydrate, trisodium phosphate, sodium sulphate, sodium chloride, magnesium sulphate, aluminium sulphate; hydrochloric acid had less action than sodium sulphate in "salting out" this dye.

The application of the above results for the explanation of the phenomena of dyeing will be seen in the following pages.

Direct Colours.—For experiments with direct colours, to which the electrical theory had not been previously applied, pure filter paper was dyed with purified direct colours, with addition of pure reagents in distilled water.

With Diamine Blue 2B, Benzopurpurine 4B, and Rosophenine 4B, and N/1750 solutions of various substances, the shades obtained increased in the order :—sodium hydrate, trisodium phosphate, sodium sulphate, sodium chloride, hydrochloric acid, magnesium sulphate. That is to say, with the exception of hydrochloric acid, which has less precipitating action on the dyestuff than magnesium sulphate has, the results are in the same order as those for the contact differences.

Aluminium sulphate precipitated the dyestuffs and was therefore not used.

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[1] Without stating more precisely, we say that dyeing has more chance of succeeding if the electric charge of the granules of colloid (dyestuff) is of contrary sign to that of the large boundary which one has to dye.

With Benzopurpurine and Rosophenine the addition of sodium hydrate up to N/875 produced a decrease in the amount of colour taken up by cellulose; further additions of alkali increased it. These results correspond very closely to the alterations in contact difference between cotton and water caused by addition of sodium hydrate, as will be seen in the curves given in the paper.

Dreaper and Wilson (*J.S.C.I.*, 1910, 1432) showed that the gradual addition of alkali (sodium carbonate) to the dyebath, first decreased and then increased the amount of Acid Anthracene Red taken up by silk. This experiment is analogous to the above.

The substances used for direct colours acted in the same order in the dyeing of cotton with sulphide colours and Croceine Scarlet, and in the mordanting of cotton with tannic acid and sodium aluminate. Pelet Jolivet and Anderson (*Koll. Zeit.*, 1908, 2, 225) found the same order in the dyeing of wool with acid colour. The same order would be expected with vat colours on cotton and with other negative mordants such as alkaline lead and chrome mordants on cotton, potassium bichromate, etc., on wool.

The substances acted in the reverse order in dyeing of basic colours on silk (Pelet and Grand, *Koll. Zeit.*, 1907, 2, 83), and this would also be expected with basic colours on wool and tanned cotton, aluminium sulphate, or other positive mordant on any fibre.

The substances lie in the opposite order for their power of fixing Diamine Blue 2B, as for assisting the dyeing.

In carrying out electrical measurements with cotton treated with various reagents, it was found that nitration increased the negative charge, mercerisation decreased it. The negative charge decreased in the order: nitrated cotton; ordinary cotton; mercerised under tension and dried; treated with 40° Tw NaOH and extracted with alcohol; mercerised without tension and dried; mercerised without tension not dried, mercerised with 80° Tw nitric acid.

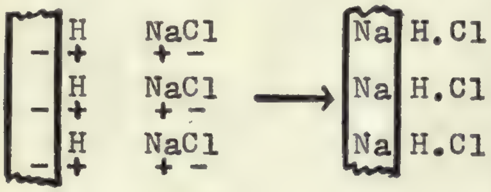


FIG. 1.

On dyeing samples of the above with direct colour, the depth of shade increased in exactly the same order as the contact differences decreased. This is again in accordance with the electrical theory.

The information collected above shows that the order in which substances influence the amount of dye taken up is the same as that in which they influence the contact charge on fibre and dye. When fibre and dye have the same electric charge an increase in the charge produces a decrease in the amount of colour taken up, but when fibre and dye have opposite charges an increase in the charge produces an increase in the absorption of colour.

In carrying out the electrical experiments one important point was noticed which explains how colours are retained by the fibres. On filtering a dilute solution of sodium chloride through a column of purified cotton, hydrochloric acid passed through. This may be accounted for by the fact that cotton takes a negative charge which causes it to absorb the positive sodium ions and leave the negative chlorine ions to combine with the hydrogen ions in the water as shown in Fig. 1.

A corresponding effect was produced with solutions of aluminium sulphate, Methylene Blue, Croceine Scarlet and Diamine Blue; in all cases the liquid issuing from the cotton contained hydrogen ions, that is to say, it was acid.

In the dyeing of basic colours on cotton, or other negatively charged adsorbent, the negatively charged cotton electrically attracts and retains the positively charged colour ion, leaving the negative ion to form free acid with the hydrogen ions in the water. The same occurs in the mordanting with aluminium sulphate or other positively charged mordant.

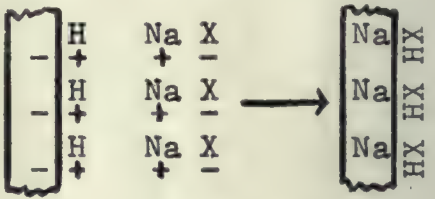


FIG. 2.

In the dyeing of cotton in a neutral bath with direct and acid colours it is again the positively charged ions which are electrically attracted by the negatively charged fibre, the negative colour ions combining with the positive hydrogen ions in the water. In this way the negative charge on fibre and dye is reduced and the electrical repulsion between them is reduced, until the colour ions arrive at the fibre by virtue of their molecular movements (or Brownian movement in the case of colloidal solutions).

In the paper by Gee and the author (*loc. cit.*) it was stated that the difference between acid and direct colours was that the free acids of the latter were generally insoluble, those of the former soluble in water. All subsequent investigations are in agreement with this statement. (The word insoluble was used as meaning, not forming a true solution in water).

During the process described above, when the negative direct-colour ions combine with hydrogen ions, the dye is coagulated either on (Fig. 2) or in the pores of (Fig. 3) the fibre. In this case we have electrical coagulation of colloids on or in the fibre substance, and the dye is retained on account of being coagulated, and not by simple electrical attraction.

The addition of salts to the dyebath reduces the contact difference of both fibre and dye so that the electrical repulsion is reduced and the coagulation of dye is facilitated.

That the dye is coagulated during the dyeing process is shown by the fact that gelatine, which, being a protective colloid, prevents or retards coagulation, reduces the amount of colour fixed on or in the fibre.

Ultramicroscopic examination of fibre seems to show that pores are present, but even if these approached molecular dimensions, they would still be accessible to some dyestuffs. Silk and wool appear to have smaller pores than cotton, and this explains why wool and silk may fix acid colours in neutral baths when cotton does not.

The fastness of a dyestuff was considered by the author (*loc. cit.*) as being due to the relation between the size of the particles of dyestuff and of the pores in which they were fixed. Since the size of the particles is governed by electrical conditions, problems on fastness may also be explained electrically.

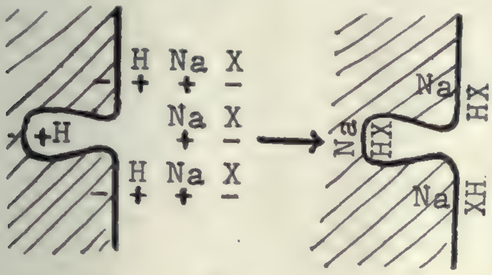


Fig. 3.

Another confirmation of the electrical theory has recently been given by Mines (*Kolloid Chem. Beihefte*, 1912, *3*, 191), who showed that complex trivalent cations had the same relation to simple trivalent cations in their action on the contact charge as on the dyeing properties of gelatine.

The electrical theory of dyeing lends itself admirably to the explanation of dyeing phenomena, and explains processes which are not chemical as well as those which may be. In applying the electrical theory, four points have to be considered: (*a*) the charge on the dye particles; (*b*) the charge on the fibre; (*c*) the size of the particles of dye; and (*d*) the surface of the fibre, including that within its pores. (The total quantity of electricity available depends on the surface.) In considering either the fixation or removal of a dye, the effect of various conditions, temperature, additions used, etc., on all these four points must be considered. Many complicated effects may arise from the relations between the alterations caused by conditions, on the points mentioned. The determination of these four factors presents many difficulties which can only be overcome by long continued and careful research.

Iron and Steel Institute.—The autumn meeting of the Iron and Steel Institute will be held at Leeds from September 30th to October 4th, 1912. An influential reception committee has been formed with Lord Airedale as chairman.

CURRENT LEGAL TOPICS.

By W. Jago, F.I.C.

In March last an action was commenced against the Uddingston Co-operative Society, Lanarkshire, Scotland, for having sold as flour an article that was not genuine, but had been bleached by the addition of nitrogen peroxide. Unfortunately, from the present chronicler's point of view, the case is not as yet concluded, and cannot, therefore, be made the subject of comment. There only remains, therefore, to give a *précis* of the most important chemical points which have arisen, reserving any criticism of same until judgment has been given. The action is of interest as being the first in Scotland of a prosecution for the sale of bleached flour, and also because of the thoroughness with which each side has presented its case. In preparing the following statement, the writer has had the advantage of perusing an excellent report appearing in the *National Association Review*.

Evidence for the prosecution was given by Dr. Wilson, M.O.H., who explained the general nature of nitrogen peroxide and its effects on flour. These included bleaching, and also changes in the fat and gluten of the flour. The amount of nitrites and also the acidity of the flour were increased. The maximum figures he had obtained for unbleached flour milled in Glasgow were 0·4 parts of nitrites per million, reckoned as sodium nitrite. The witness was strongly of opinion that artificial bleaching was a totally different process to the loss of colour resulting from the natural ageing of flour. He regarded 30 c.c. per kilo. as being about the quantity of nitrogen peroxide used in ordinary bleaching. Nitrites might be present in a flour which had not been artificially bleached, but such presence would not affect the genuineness of the flour.

Dr. Benjamin Moore, of Liverpool University, was the next scientific witness. He strongly insisted on the poisonous nature of nitrogen peroxide, and the marked absorptive powers of fat and proteins for this body. Further, that the nitrous and nitric acids produced when nitrogen peroxide came in contact with flour were powerful drugs which, when used in medicine, were employed in small doses and with very great care. As a result of subjecting the lecithin of egg-yolk to the action of nitrogen peroxide, he found it to be changed from a most valuable food to a highly dangerous substance. Even with so low a quantity as 20 c.c. of peroxide to a kilo. of flour, the fat was materially altered, the percentage of nitrogen was increased, the iodine value diminished, and the fat rendered physiologically less valuable. The gluten of the flour was also altered, and the nutritive and bread-making properties of the flour were deteriorated. He further suggested that although the quantity of nitrites introduced was small, they might in years injuriously affect the health of the person consuming them, since they were such powerful drugs. In cross-examination, Dr. Moore admitted that he had made no experiments with bread, but believed that the amount of free nitrites was reduced in baking by one-third; but this did not mean that the properties introduced by nitrites had disappeared from the bread.

> "His opinions of the result of bleaching with low strength of gas were gained from deductions based upon the results obtained with a strong bleach. He had no other way of getting the information, and it was the usual method followed by the chemist. It was a just inference."

Mr. Edie dealt with the action of nitrogen peroxide on the diastatic enzyme of flour, which was affected by variations in the degree of acidity present.

Dr. Watson related the results of feeding experiments made by himself on litters of young rats, which he fed on unbleached flour, and flour bleached by the addition of 60 c.c. of nitrogen peroxide per kilo. respectively. The mortality among the animals fed on the bleached flour was appreciably higher, while their weight was appreciably less.

Mr. Thompson, public analyst, Glasgow, adduced the results of a series of samples of flour analysed by him. On treating one kilo. of flour with 15 c.c. of nitrogen peroxide, the nitrite was raised from 0·37 to 12·20 parts per million. Unbleached flour contained from 0·1 to 0·7 parts of nitrites per million. Bleaching by the addition of the peroxide was not the same as that by exposure to the atmosphere; thus 5·1 parts per million of nitrites introduced by artificial bleaching, discharged the colour far more than did 8·2 parts absorbed by exposure to the atmosphere in the dark. Flour exposed to the air in thin bags absorbed nitrites and was bleached. Mr. Thompson had tested the air of Roseneath, where pure, and in the heart of Glasgow, and had found that it was distinctly alkaline. So also, flour contained no free acid. The nitrous acid present in air was probably in the form of ammonium nitrite. If bleaching were carried out by 2 c.c. of nitrogen peroxide per kilo., the resultant effect was too small to be of value. In cross-examination, the witness agreed that very low treatment with peroxide might have no effect on the soluble proteins of flour, but in accordance with chemical ideas he would expect a relative effect. He admitted that in the event of there being free acid in the air, the differentiation between artificial and natural atmospheric bleaching would disappear. The witness further stated that a flour which had not been touched by artificial agency might become non-genuine by absorption of atmospheric nitrites as it lay upon a grocer's shelf, and even that from the same cause the top-half of flour in the same bag might become non-genuine, while the bottom remained genuine.

Mr. Clark, public analyst, corroborated much of the previous evidence. He found that thirteen samples of wheat when ground in a pure atmosphere showed no reaction for nitrites, while in three samples, nitrites were found to the extent of from 0·05 to 0·30 parts per million. Whether flours were artificially treated with nitrogen peroxide, or had been allowed to absorb that gas from the atmosphere, they contained in each case increases in soluble proteins and carbohydrates, though in the former instance the increase in soluble proteins was so small as to show a difference in the fourth or fifth decimal place only. The witness further admitted that it was possible to have no change at all if the proteins were subjected to the influence of the gas for a considerably less time. The increase in acidity and change in iodine value were also very small.

Mr. Otto Hehner, London, expressed the opinion that the natural loss of colour of flour which accompanied ageing was not due to the absorption of nitrous gas from the atmosphere, even if present there. Analysis of bleached flour showed that only about one-fifth of the original quantity of nitrite in the flour survived a fortnight after the bleaching, the remaining four-fifths being used up in producing alterations in the flour. Among other substances, the amino bodies were reacted on by the nitrous acid. Bleaching was injurious inasmuch as it caused a retardation of digestion. A substance which had profound physiological influences in itself or when administered in larger doses was not likely to be devoid of those injurious influences in that doubtful zone where the analyst could not trace its action. The largest quantity of nitrite he had met with in unbleached flour was 1·6; and if he had found the same nitrite content in a flour which had been artificially bleached, he did not think, as an analyst, that he would be able to find any difference in the constitution of the one from the other.

Dr. Patterson, Lanarkshire, had counted microscopically the number of particles of offal (hair, epicarp, etc.) he had found in different grades of flour. These were far more plentiful in the lower grades. The result of bleaching was that a flour containing a large proportion of fragments of offal was lightened in colour to match a flour naturally containing comparatively few of such particles.

For the defence, Mr. Ballantyne, of London, was called. All tests for nitrites in flour were liable to plus errors, due to absorption of nitrous gases from the atmosphere. The actual amount of nitrites in the flour on which the prosecution was based was exceedingly small; 3·43 parts per million equalled 0·00042% or 1 lb. in 130 tons. The food value of the lower grades of flour was slightly greater than that of the higher grades, so that in this respect the bleachable flours were not inferior to the so-called first-grade flours. In the matter of colour, in nature exactly the same process was going on as that due to artificial bleaching. In bleaching by natural ageing, increase of acidity and soluble extract proceeded concurrently, with the margin of safety in keeping properties of the flour gradually decreasing. Artificial bleaching by whitening it instantaneously added to the life of the flour. The modern bleaching apparatus absolutely controlled the amount of nitrogen peroxide to which the flour was subjected. By means of a switchboard, the electric current, to which the bleaching air was subjected, was regulated, there being five stops or knobs on the board. He had tested flours bleached with these various strengths of current; with the first or lowest, there were 0·9 parts of nitrites per million, of which 0·15 were due to bleaching; with the second strength, 1·2 parts, due to bleaching, 0·8; third strength, 1·9 parts, due to bleaching, 1·5; fourth strength, 2·1, due to bleaching, 1·7; and fifth or maximum strength, total 2·4, due to bleaching, 2·0 parts per million. Nitrites were indigenous to wheat; he had found 0·3 parts in the grain, and nitrous fumes were continually being absorbed from the air from the first crack of the wheat in milling. The sample of flour complained of was alleged to contain 3·43 parts per million, whereas when he received the defendant's official portion for analysis the nitrites amounted to 11 parts per million, so that by absorption from the atmosphere they had increased by 7·5 parts.

> "It was neither scientifically nor chemically accurate to infer, as the expert witnesses for the prosecution had done, that because certain results were obtained by using a particular power, therefore like proportionately smaller results would be obtained by using a lower power."

Bleaching caused no reduction in the iodine value of the fat of the flour, the figure for the unbleached flour being 106·1, while a flour bleached at the fifth or maximum strength gave 106·6. The enzymes were not injured; neither was the strength nor quality of the gluten. Commercial bleaching affected neither the baking quality of the flour, nor the baked loaf. The salivary and peptic digestion of flour, glutens, and breads were not impaired by commercial bleaching. Nitrites greatly in excess of the amount in the official flour sample were taken into the human system daily, and were even present in the saliva. Tests made on five subjects showed that the nitrites in saliva varied from 1·0 to 3·5 parts per million. London air, which was, if anything, purer than that of Glasgow, unquestionably contained nitrous acid. It was not possible to say from the mere presence of nitrites in flour whether the flour had been bleached artificially or naturally.

Dr. Willcox, London, spoke as to the effect of the alcoholic extracts of bleached flour on rabbits, and had observed no adverse symptoms. He did not think that any conclusions at all could be drawn from Dr. Watson's tests on rats as the quantity of nitrogen peroxide used in the treating the flour was so enormous (60 c.c. per kilo.). In commercial bleaching the pancreatic digestibility of the flour was not impaired, and no injurious results followed. Salivary digestion tests were not satisfactory without gelatinising the starch, and in the absence of that condition Dr. Watson's experiments were unsatisfactory.

Mr. Gregory, Glasgow, gave the results of direct experiments as to the absorption of nitrous fumes from the atmosphere by unbleached flour in the actual shop from which the official sample of flour had been taken. The amount of absorption in a fortnight was as follows:—In paper bag, 0·7 nitrites per million; in linen bag in store-room, 1·8; in linen bag in back-shop, 5·2 parts per million.

Dr. Liebmann, Manchester, denied that commercial bleaching had any injurious physiological effect on flour. Nitrites were present in a large number of foods, in the air, and in most waters. All commercial flour contained nitrites. Commercial bleaching had no effect on the constitution of flour.

This concluded the scientific evidence in the case. Further comment will be made after the delivery of judgment, together with an examination of certain principles of chemical science suggested by the various witnesses.

Heusler Alloys.

The following is a summary of a paper communicated by Dr. E. Take (Marburg) and Dr. F. Heusler (Dillenburg) to the Faraday Society.

1. In order to account for the pronounced ferromagnetism of the Heusler alloys, aluminium or tin-manganese bronzes, Guillaume assumes with Faraday that pure manganese exists in a strongly magnetic modification, which undergoes transformation at a very low temperature; this temperature is said to be raised by the addition of Al or Sn, so that the magnetism of these alloys becomes apparent. This hypothesis is not based upon facts, and the arguments are not sufficiently supported; it would, moreover, not explain the strong ferromagnetism of the Heusler manganese alloys with As, Sb, Bi, and B.

2. Heusler, on the other hand, has advanced a hypothesis which perfectly explains all the phenomena; for he has not only discovered the ferromagnetic manganese alloys, but he has also first proved, in 1903, that the appearance of the strong ferromagnetism is due to the formation of chemical compounds, and that the ferromagnetism is thus a molecular phenomenon.

3. It is stated and demonstrated in detail which these strongly ferromagnetic chemical compounds are. (Heusler, Haupt, Preusser, Williams, Ross, Hilpert.)

The research above referred to proves the Heusler Al-Mn bronze to be, in physical respects, exceedingly interesting material, of valuable properties, especially as regards hysteresis.

4a. By the process described by Heusler the malleable Al-bronzes in particular can be converted into an unmagnetic modification which, suitably aged, yields a strongly magnetic material of very small hysteresis. (Heusler Asteroth, Take.)

4b. By the method of Take the malleable Al-bronzes in particular may, by another ageing process, be transformed into a permanently magnetic modification of exceedingly high intensity.

5. Hypotheses for explaining the strong ferromagnetism of the chemical compounds on the electron theory have been suggested by Richarz, Weiss, and Take.

6. The physical properties mentioned under 4a are due, according to Richarz, to a very slight formation of complexes of the elementary magnets in the one case, and to a very pronounced formation of such complexes in the other case.

7. According to his experiments the phenomena of ageing are due, according to Take, to *two* transformations.

CORRESPONDENCE.

To the Editor of THE CHEMICAL WORLD.

SIR,—Much has already been said and written upon the question of introducing organised instruction in Chemical Technology into Colleges, though no satisfactory conclusion has been derived, and many educationalists regard the continuation of this discussion as futile.

Nevertheless, perhaps one may be permitted to make a few further suggestions in regard to this subject.

If any conclusions can be drawn from the discussions, one of the most agreed upon opinions is that it is impossible to teach students within a college how to deal with technical problems, because certain necessary factors occasioned by the demands of trade cannot be imitated in the college, which factors vary for different branches of industry.

It is stated that it is better to import science into the works than to attempt to introduce the varying conditions of trade within the college walls. Yet it is readily admitted that in a large proportion of the factories of this country there are immense economies to be effected and continuous waste to be prevented if only the right kind of men are available to deal with such problems.

This has been felt to be a question of national importance, and much public and private money has been expended on Technical Colleges with a view to training such men.

Yet comparatively few of these are utilised in the way intended, and this is not altogether the fault of the manufacturers, for they frequently do not know how to use them, and the men themselves are quite unable to apply their knowledge and thinking powers to practical problems. So that a trial frequently results in the chemist acting merely as an analyst without the power of interpreting his results.

Now a college does not train a man in the mental processes of applying knowledge, or teach him to take into consideration all the factors which obtain in the commercial world.

This deficiency cannot be made up in the factory because the purpose and organisation of a factory are directed to manufacture and to the fulfilment of orders with the ultimate view of pecuniary profit. Consequently the training of students or apprentices becomes, even with the best intentions, entirely subservient to the needs of the business, and little attention is given to it.

Again, the principals are rarely able, nor is it reasonable to suppose that they might be willing, to give access whereby students may gain knowledge of processes and details of business which would assist a competitor.

The writer thinks that it is not impossible to establish conditions under which chemical technology could be taught in a college or an institution devoted to the purpose. This would entail the provision of a working factory attended by students already graduated who had previously attended courses in Chemical Technology, including Engineering and Building Construction, the Properties of Materials used in Construction, Modern Methods of Costing and Accounting, Fuel Economy, Steam Production, etc.

It would be essential that this factory should actually produce, that its products should be varied, and that some of them should become distributed, preferably by sale, so that they are subjected to public criticism.

Such conditions would be met if the institute supplied organic and inorganic chemicals manufactured on a moderate scale for use in various educational establishments and research laboratories. By selling only in such a market there would be very little, if any, opposition from the manufacturers in this country.

The factory would be well equipped with workshops and plant suitable for a large number of typical operations, but not much of it for highly specialised technical processes; though models of such apparatus and typical works would be employed.

The strictest principles of management as regards attendance, economy, costing, analysis, discipline would be observed, and the whole conducted in such a manner that the students got an insight into the efficient control and administration of a modern factory.

All operations would have to be made quantitative as regards the yield, cost of material, amount of energy required, and would have to be accurately recorded by the student, while the time and labour employed would equally be made matters of importance.

The students would be taught to work out costs. The problems set to them would be such as to test and develop their resourcefulness, they should learn to avoid useless operations and to obtain the maximum of product with the minimum of unprofitable labour.

They should be taught to test materials quantitatively for minute amounts of impurities derived from raw material or from the plant, special attention being devoted to the speed of their analytical work.

The men who control and manage at present fall into two classes, those with scientific training and those having a rule of thumb knowledge based on a good business instinct; it is a combination of these which is required. Under the present system it rarely exists in young men, for those possessing a scientific training rarely get the opportunity to acquire this before the energy and enthusiasm of youth have evaporated.

Yours faithfully,

3rd July, 1912. FRANCIS H. CARR.

Institute of Chemistry.

PASS LIST: JULY EXAMINATIONS, 1912.

Of 35 candidates who presented themselves for the Intermediate Examination, 18 passed: C. A. Adams, B.Sc. (Lond.), Miss D. J. Bartlett, L. O. Brekke, B.Sc. (Leeds), H. B. Brown, F. G. Conyers, E. D. Goddard, B.Sc. (Lond.), J. R. Gray, F. A. Hatch, M. Howie, D. W. Kent-Jones, E. Marsden, Miss E. G. Mocatta, B.Sc. (Lond.), E. A. Rayner, B.Sc. (Lond.), W. S. Ritchie, B.Sc. (Lond.), W. G. Saunders, D. E. Sharp, B.Sc. (Aberdeen), T. F. Smeaton, and W. A. Storey. Of 37 candidates who presented themselves for the Final Examination, 28 passed. In the branch of Mineral Chemistry: C. R. Chown, A.R.C.S. (Lond.), B.Sc. (Lond.), H. Gilmour, W. P. Harmsworth, J. G. King, H. Knight, P. G. Knapman, B.Sc. (Lond.), and R. H. Truelove, B.Sc. (Lond.), A.R.C.S. (Lond.); in the branch of Metallurgical Chemistry: E. O. Jones, B.Sc. (Lond.), A.R.C.S. (Lond.), W. A. C. Newman, B.Sc. (Lond.), A.R.C.S. (Lond.), and E. W. Yeoman, B.Sc. (Lond.), A.R.C.S. (Lond.); in the branch of Physical Chemistry: J. I. Crabtree, B.Sc. (Vict.), and Miss A. M. Finney, B.Sc. (Birm.); in the branch of Organic Chemistry: J. L. S. Allan, J. Crawford, G. J. Eastburn, J. H. Naylor, M.Sc. (Manc.), F. G. Rawling, M.Sc. (Leeds), S. Robertson, A. Wilson, T. A. Wilson, and T. Wright; in the branch of the Chemistry of Food and Drugs, and of Water: S. W. Bunker, B.Sc. (Lond.), D. H. B. Cowman, B.Sc. (Lond.), A. Gemmell, B.Sc. (Edin.), C. L. Hinton, H. Raistrick, B.Sc. (Leeds), M. J. Robb, B.Sc. (Aberdeen), and S. B. Tallantyre.

CHEMICAL ENGINEERING.

A WATER TUBE BOILER FOR ATOMISED FUEL.

By J. G. Davis, B.Sc. (Eng.)., A.C.G.I.

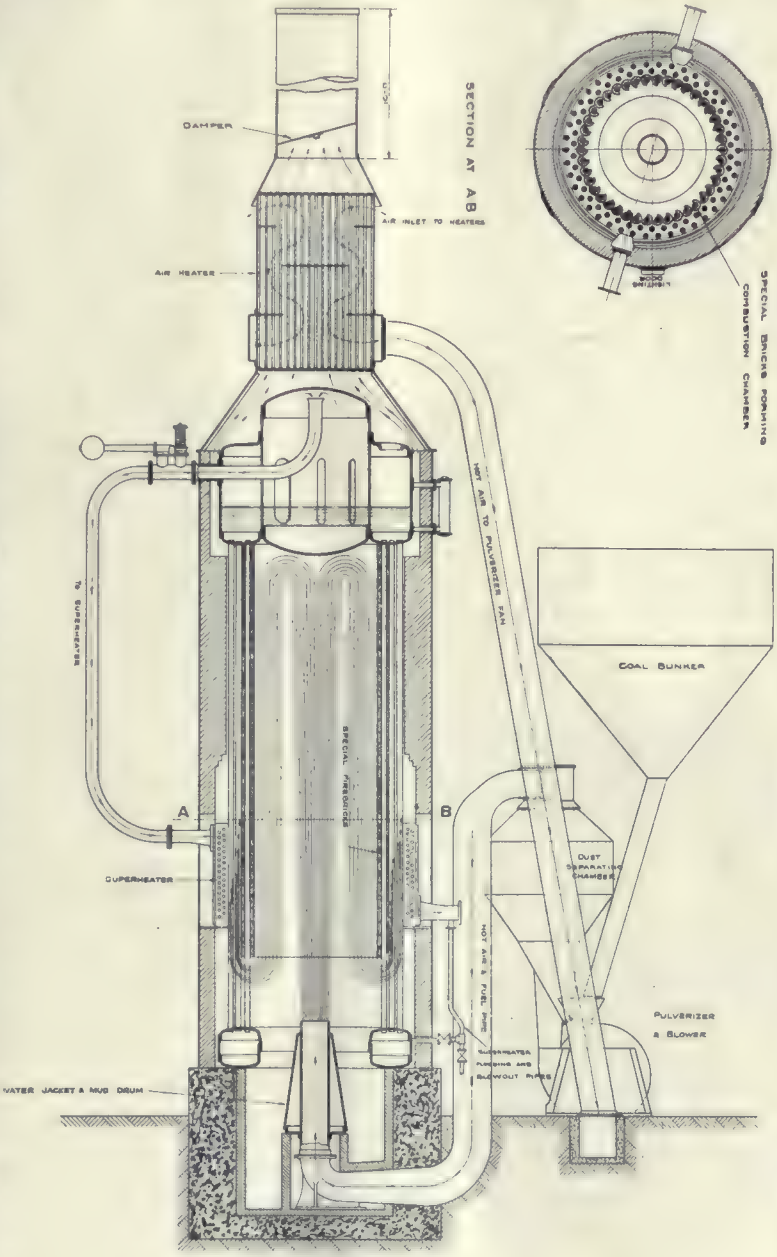


Fig. 1.

The recognition of the fact that perfect combustion of a finely pulverised fuel in the presence of a proper proportion of air can be secured without risk of explosion, although with true gases the rapid progress of the explosion zone often necessitates confinement to a cylinder, as in internal combustion engines, has led to the construction of the special type of boiler about to be described.

Former attempts to turn to practical use the advantages resulting from the burning of fuel in the form of dust, except in the case of burning cement in special kilns, have been debarred from success commercially by such serious difficulties as failure to find for use in the various types of furnace employed a material which is both economical and capable of withstanding the high uniform temperature necessary for the maintenance of steady and continuous ignition; the poor efficiency due to failure to construct a solid fuel carburettor capable of maintaining a homogeneous mixture of fuel, dust and air, a difficulty particularly marked when the various grades of coal employed are wet and high in ash; and, lastly, the practical drawback to the slag deposits formed by the ash accumulated in a molten state on the parts of the furnaces hitherto employed.

The Bettington Boiler has been constructed to successfully overcome all these difficulties. It is of comparatively simple design, and, while comparing favourably as regards efficiency and initial cost of installation with other well-known makes of water tube boilers, has the advantages of effecting considerable savings in the running costs, and of being able to work continuously under conditions of fuel supply which would cause injury or at least temporary shut-down of boilers of other types.

It has also certain other good points, to be mentioned later.

The standard construction is indicated in the sectional elevation and plan of Fig. 1, the coal being fed by hand or mechanism into a hopper or bunker placed above the pulveriser and blower. By means of a "worm" feed, controlled by a variable speed friction wheel, the rate of fuel supply down the chute to the latter may be adjusted, and the air drawn in by the pulverising fan, which also acts as a blower, is pre-heated at the top of the boiler by the gases which have been passed through the boiler proper, steam superheater and feed section, or economiser, when provided, on their way to the stack.

This increases efficiency and also facilitates the disintegration and burning of coals containing up to 15 % of moisture or more. This air heater may with advantage be separate from the stack in larger sizes, and the pulveriser may be in duplicate. The air supply is adjusted as desired by slides or valves provided in the pulverising fan, and the latter passes the disintegrated fuel into the dust-separating chamber, from which the particles sufficiently fine are carried with the heated air to the fuel nozzle, and all coarse particles are returned by gravity to the blades for further reduction in size. It is to be noted that the life of these steel blades is considerable, but that each is capable of immediate replacement if necessary. One set appears to last some 1,600 hours.

The commonest method of driving the pulverising fan is by an electric motor, a flexible coupling being used, though the means which best meets local conditions is naturally employed, the cost of maintenance of the apparatus and the cost of power (some 2 % to 3 % of the boiler capacity) needed for operating this portion of the plant being the one factor which tends to reduce the saving which is effected by the use of cheap fuel—such as oils, waste gases, or mixtures of gases, and very dirty coal or slack.

The application of a lighted torch to the central vertical fuel nozzle, through which the fuel dust and air is being fed, is all that is necessary to fire up the boiler when cold; the torch may then be extinguished and the coal feed set to any rate desired. Continuous ignition of the coarse gas, formed by intimate mixing, before it enters the furnace, of the incoming stream of dust and air then follows.

The flame produced is of mushroom shape, the combustion of each particle commencing at the stem, becoming most intense soon after, proceeding as the particles travel upwards, due to their velocity of projection, and becoming complete in a time dependent upon the size of the particle. Following out the complete cycle of events in the case of a coarse particle, the solid is safely assumed to enter the furnace through the tuyere or fuel pipe at the same considerable velocity as the air carrying it, since the solid theoretically forms only some 8 % of the total weight, and infinitely less of the total volume of the mixture.

Owing, however, to friction and expansion of the air, and to the greater momentum of the solid, the latter is retarded less than the hot air with which it is rising, with the consequence that the combustible particle rises relatively to the air and continues to extract oxygen from the portions as yet unexhausted, and to decrease in weight as it travels. On falling, either by gravity or by striking the water top of the furnace, the particle is so accelerated by gravity as to equal or exceed the velocity of the descending current of gases, which now come into direct contact with the firebrick, forming a closed ring with the inner row of vertical water tubes which form part of the steam producing plant. The important advantage attained, by the action of gravity and momentum, both in a vertical direction, and proved by practical results, is that motion of the dust relatively to the air at all times secures complete combustion (provided that the particles are not too large to burn away during the up and down journey), and that any concentration of the coarser particles, such as has resulted from horizontal stream line flow, is avoided.

Separation cannot occur in a continuous stream of mixture, however greatly the specific weights of the constituents may differ.

It is shown, therefore, that the air may with advantage be reduced towards the theoretical amount required for the reactions involved, and that there is no need for excessively fine grinding.

The mixture of gases returning downwards (principally CO_2, H_2O and N) yield their heat at a temperature of about 3,000° F., to the firebrick, rendering it incandescent around the tuyere. This sheath of gases prevents destructive "blowpipe" action by the intense zone; at the same time the "self igniter" (the position of which is independent of the velocity of the incoming stream), without preventing the transmission of radiant heat to the firebrick and tubes forming the walls of the combustion chamber.

It is proved by experiment that the employment of the highest feed velocities practicable does not cause a rise of more than 10 % in the point of ignition. The capacity for heat of the brick lining is sufficient to restart the fire after a temporary shut-down, as soon as the fuel supply is turned on.

The ash of the fuel, when passing through the high temperature zone, forms a liquid spray, a portion of which, striking the firebrick lining of the furnace, automatically seals up all holes and crevices which would allow of short circuit of the gases, with loss of efficiency in consequence.

This dispenses with the use of fireclay, making it possible to re-line a boiler by merely stacking up a cylindrical wall of firebricks of special shape, the spray cementing them together into a solid mass, in a short time making a perfect lining of fire-resisting material with glazed enamel-like surface.

The improvement in the efficiency of a boiler as this sealing up proceeds after re-lining is noticeable, and the life of such a lining is a very marked improvement on ordinary fireclay.

The portion of the ash which fails to so adhere is kept in a molten state by the downcoming gases and strikes the "dripping" edge of the furnace itself.

Adherence to the water cooled surfaces being impossible, it falls clear into the ashpit, where it is chilled sufficiently to prevent its fusing with the former or succeeding drops. This makes the process of raking out once every 24 hours an easy one, the slag being in small globules or manageable clots. The chances of scale deposition or of burning or blistering are much smaller than usual, owing to the circulation of the water being very rapid.

Each vertical solid drawn-steel tube is connected to mild steel top and bottom headers, and every facility for inspection and cleaning has been provided in the construction, a feature of which is the symmetry, resulting in minimising abnormal expansion stresses produced in firing up rapidly.

Nature of Fuel.	Nuts.	" Dant."	South African.	South African.	Welsh Fines.	Slack.	Slack.	Slack.
Lbs. fired per hour (dry)	1,084	1,020	1,347·8	1,183·5	1,242·2	897	2,078	2,733
Ash (per cent.)	22·18	23·00	21·30	19·92	12·64	14·33	16·2	14·33
Percentage volatile matter ..	25·97	20·00	27·68	22·94	11·66	32·55	16·57	32·55
Sulphur (per cent.)	—	—	0·95	0·76	0·99	0·99	0·93	0·99
Fixed carbon (per cent.)	51·85	57·00	51·02	57·14	75·70	52·13	66·3	52·13
Cal. value on dry coal (B.Th.U.) .	8,710	10·700	10·494	11·088	12·276	11·870	9·648	11·870
Thermal efficiency based on coal .	79·3	75·0	77·35	80·30	74·59	79	75·6	66
Percentage of moisture in coal as fired	8·66	15·6	2·00	2·4	0·8	3·85	14·39	3·85
						Normal load.	50% overload.	100% overload.

The colour of the flame or the indications of a CO_2 recorder, enable the supply of air to be regulated so as to obtain almost smokeless and perfect combustion. An average 16% to 17% CO_2 record is not uncommon over long periods.

The Bettington boiler has a strong point in the rapidity with which it can be fired up, it requiring only 20 minutes to raise full steam pressure from cold water, and correspondingly less when hot, so enabling units to be easily started or cut out as the demand varies. The overload capacity is remarkable, a fact established by several years of experience..

In cases where mills, etc., are driven by these boilers, the firemen are not allowed to start the cold boiler more than half an hour before full yield is expected from them.

The boilers also tend to reduce running expenses from the fact that they burn fuel only in suspension, and cease to do so immediately they are shut down, just as in a gas jet, the losses due to banked fire being eliminated.

Other notable points are the reduction possible in the size of the chimney stack, and the freedom from smoke at all rates of firing, provided that attention be paid to the coal and air feed, each alterable instantaneously.

The great advantage lies in the high efficiency yielded when burning in atomised form fuel of very poor quality, fine slacks, or coal dust. For instance, the 55% thermal efficiency obtained by hand-firing screened and picked low grade coal, in South Africa, was increased to over 80% by a dust-fired Bettington Boiler.

The boilers are made in five standard sizes at present, ranging from 6,000 to 50,000 lbs. normal evaporation from and at 212° F. per hour.

We had the opportunity of viewing under load one of rated capacity of 10,000 lbs. of steam per hour, which has been in service with Messrs. Fraser and Chalmers (Erith), the manufacturers of these boilers, for over three years, and has worked at good efficiency up to 22,000 lbs., or nearly 10 lbs. of steam per square foot of heating surface.

In this many low grade coals, and even dust-destructor refuse, have been burnt. We also saw, during the coal strike, one running at the Erith Council's supply station, the fuel being of very poor quality, the only stuff then available in their yard, and one that would have been useless in an ordinary boiler, hand or mechanically stoked, owing to caking.

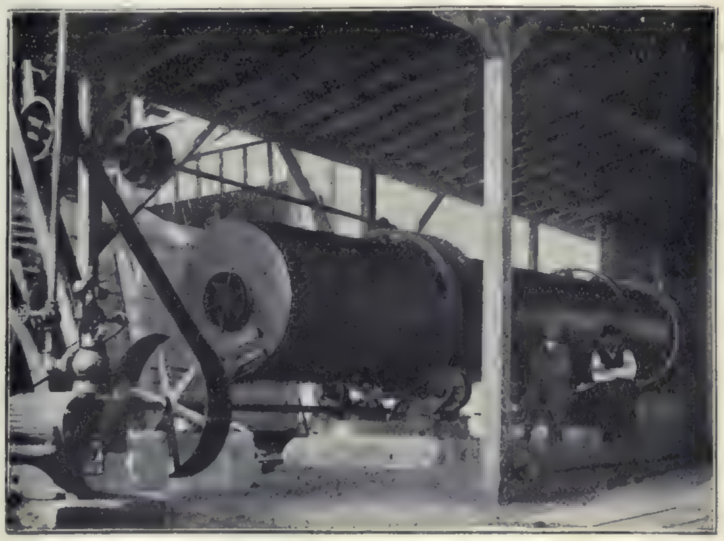
The detailed results of expert tests in hand show (without economiser efficiencies) as above.

Further official tests in Johannesburg yield 77.5% to 81% efficiency with steam superheated to 600° F., these trials being made with coals containing roughly the following percentages: Ash, 20; fixed carbon, 47; volatile matter, 23; moisture, 10.

DRYER EFFICIENCY.

By F. W. Poynor.

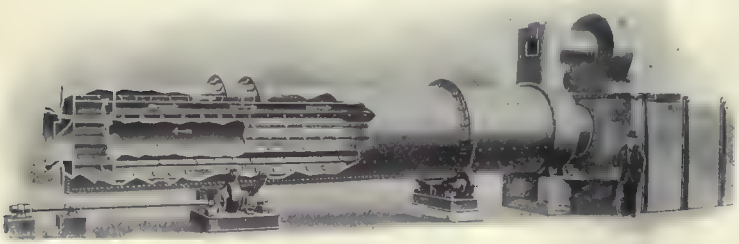
There has been considerable discussion recently among engineers as to the proper way to calculate the efficiency of a dryer in doing the work of evaporating moisture from any material. Some engineers who are familiar with boiler practice



Apparatus for Drying Glass Sand.

claim that as evaporation of the water out of material is the sole aim in a drying operation, the only proper way to figure the efficiency is to take account of the water only.

The writer, among other engineers who have studied the problem, believes this to be incorrect. In order to dry any substance in an economical manner it is necessary to raise the temperature of the material, and as the sensible heat required to do this is a part of the operation, it should be taken into consideration.



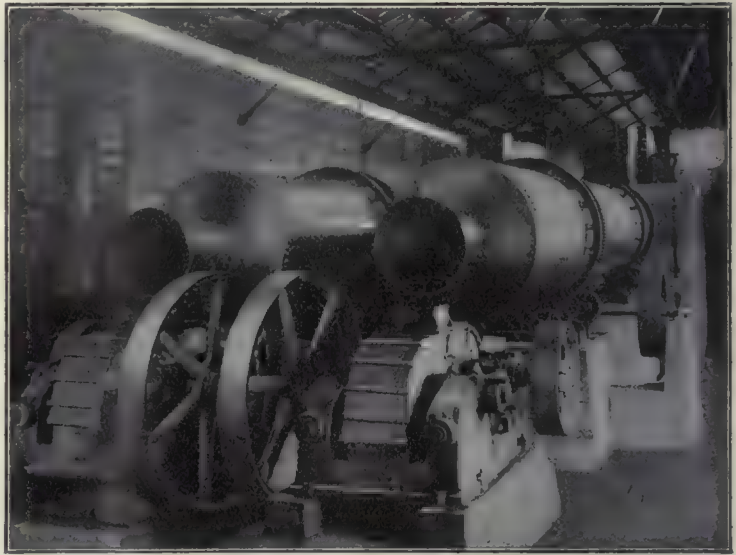
SECTION SHOWING DIRECTION OF GASES.

Some substances, such as sulphate of ammonia, bichromate of potash and other salts, cannot be heated to a high temperature, but as most substances may be heated to 212° or higher without injury, we will consider these only for the present.

COMPARATIVE EFFICIENCY OF SIMILAR DRYERS WITH DIFFERENT MATERIALS.

1. Material to be dried		Sewage cake.	Rock.
2. Original percentage of moisture		60	3
3. Final percentage of moisture		10	0
4. Total moisture in original material per dry ton	lbs.	3,360	69
5. Total moisture in finished material per dry ton	,,	248	0
6. Total moisture to be evaporated	,,	3,112	69
7. Specific heat of material		·3	·21
8. Theoretical heat required to raise temperature of 1 ton of material 60° to 212°	B.T.U.	102,144	71,500
9. Theoretical heat required to raise temperature of contained water 60° to 212°	,,	510,720	10,488
10. Theoretical heat required to evaporate moisture	,,	3,019,885	66,957
11. Total theoretical heat required to do drying	,,	3,632,749	148,945
12. Amount of fuel of 14,000 B.T.U. calorific value required per ton of dry material	lbs.	345	14
13. Total heat in fuel used per ton	B.T.U.	4,830,000	196,000
14. *Thermal efficiency No. 11 ÷ No. 13*		75·21%	75·99
15. Water evaporated per lb. of coal, No. 6 ÷ No. 12	lbs.	9·02	4·93
16. Theoretical evaporation from 60° with coal of 14,000 B.T.U. value = 14,000 ÷ 1122·4 = 12·47 lbs.			
17. Efficiency of dryer considering evaporation of water only, No. 15 ÷ No. 16		72·34%	39·53%

It will be noticed in the above that if the sensible heat required to raise the temperature of the material is taken into consideration the efficiency of the dryers is each slightly above 75%, while if the amount of water taken out in each case only were considered, one dryer would be nearly double the efficiency of the other, although they are both of the same size and type, which is rather an absurdity. Thus, in estimating the water only, no standard of efficiency could be stated which would cover all conditions, and a different efficiency would have to be stated for each different percentage of moisture, while if all the elements of drying are taken into consideration, a broad claim on this type of dryer can be made of over 75% thermal efficiency, whatever the conditions may be.[1]



APPARATUS FOR DRYING ROCK.

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[1] Electro-Metals, Ltd., 9½ Union Court, Old Broad Street, E.C.

THE CHEMISTRY OF A BEET SUGAR FACTORY.

By Francis V. Darbishire, B.A., Ph.D.

Very various opinions are held regarding the employment of chemists at beet sugar factories. It will be admitted by every one, however, that it would be as great a mistake to be quite without chemical control as it would be to rely wholly on the chemist. An experienced factory hand can occasionally by certain external signs detect irregularities before samples have been brought into the laboratory and been analysed by the chemist in charge. And after all, samples are usually taken at fixed intervals; it is therefore conceivable that the chemist might fail to detect the trouble in time, or it might even escape him altogether and therefore, unless the chemist himself possesses technical knowledge, he should always be in close touch with the technical overseer. Of course only a trained chemist and thoroughly reliable analyst can perform the analyses required by every factory—the analyses of the finished products, for instance, before they leave the factory; only a chemist can control the loss of sugar by carefully analysing certain bye-products which invariably carry away a varying amount of sugar, such as lime cake, exhausted beet slices, and so forth. A chemist will also be called upon to examine various kinds of material which are made use of for different purposes at all sugar factories, such as coal, water, saturation gas, lime, and so on.

The sugar chemist of to-day has at his disposal a number of very excellent apparatus. They are devised to lessen labour; consequently the chemist can get through his analytical work at a very quick rate and yet depend on the results being sufficiently accurate. I propose to give a short account of one or two of them :—

The balances are usually supplied with weighing dishes accurately counterpoised by weights with corresponding numbers; also with weights specially made for sugar analysis, corresponding to normal weight, half normal weight, and so forth, in order to save time in weighing out the necessary amount of the substance to be analysed.

Polarimeters when employed to determine the quantity of sugar directly on a scale are called saccharimeters. In addition to the ordinary polarisers most laboratories also employ saccharimeters with scales limited to 35°. This scale is large and can be read to tenths of a per cent. with the naked eye; it is therefore much less fatiguing and more rapid than a scale which can only be observed with the help of telescope and vernier. It is generally worked in conjunction with a Pellet's continuous flow tube which remains permanently in the trough of the polarimeter, and at each end of which a small tube is attached which opens into the interior; by means of a syphon arrangement the fresh juice is in a very simple manner drawn in and replaces the earlier one. Both of these plans can be strongly recommended when a large number of solutions are to be polarised in rapid succession, as for example where beets are still analysed daily.

The indirect method of beet analysis which consists in determining the sugar in the juice expressed from ground samples of beet and multiplying the result by the juice factor 0·95 is not reliable, inasmuch as the latter is a variable quantity. Krüger's cold water digestion method does not pretend to be scientifically exact; but as it is simple and quick and sufficiently accurate for ordinary purposes it is the one usually employed for rapid work in preference to the other recognised methods. It is based on the theoretical proportion of 1 to 3 between normal weight and lead acetate water, which is added to remove colouring matter and optically active non-sugars. Each one of Frühling's automatic pipettes of known volume is supplied with a corresponding weight; pipette and weight being numbered to correspond. A 79·2 pipette, for example, would have a counterweight of $\frac{79{\cdot}2}{3} = 26{\cdot}4$ gr. With the help of this counterweight, weighing 26·4 gr., samples obtained from the beet by a borer attached to a rapidly revolving machine are weighed in large nickel crucibles, all of which have exactly the same weight and, therefore, the same counterweight; 79·2 c.c. lead acetate water are run in from the automatic pipette, the whole stirred for a short time, filtered, transferred to Pellet's continuous flow tube, and the results read off on a polarimeter with limited scale.

Hydrometers or areometers as constructed for technical purposes are not very accurate, but are everywhere used because they are so easily handled. Instruments which indicate directly the sugar percentage, without the help of tables, are termed saccharometers. Balling constructed the first of this kind; it was restandardised by Brix and now goes under his name, and may simply be described as an hydrometer specially graduated for sugar solutions or one on which the degrees show directly the percentage of sugar; in other words, an aqueous solution of pure sugar reading 25° Brix on the scale contains 25% sugar. Though Brix areometers are standardised for solutions of pure sugar only, they are employed for determining the total solid matter in impure juices. Theoretically this is incorrect, inasmuch as the specific gravity of non-sugars differs from the specific gravity of pure sugar. For technical purposes, however, it is sufficiently accurate to take Brix degrees as equivalent to percentage of total solid matter. A diffusion juice, for example, with 14·5° Brix, therefore has 14·5% solid matter and by difference 85·5% water. The true percentage of total solids is determined by driving off the moisture from a known weight of the substance in a steam oven. By weighing before and after, the percentage of moisture can be calculated. A very rapid and simple method can be carried out with Abbé's refractometer. It is based on the fact that light passing through a sugar solution is refracted more or less according to the amount of sugar dissolved in it. The refractive index determined with this instrument gives directly, with the help of tables, the percentage of total solids. The greater the index, the larger the total solids, the smaller the amount of water.

The lime content in juices after saturation with CO_2 is called alkalinity and is a very important factor. The men in charge of these stations are supplied with an automatic filling burette, phenolphthalein as indicator, and a standard H_2SO_4 solution of such strength that 1 c.c. is equivalent to 0·001 gr. CaO. The burette is charged by means of a rubber bulb, which, when gently pressed, forces in the acid, any excess of which, above the zero mark, is automatically syphoned off, so that the operator cannot well make a mistake in filling the burette to the zero mark. When 10 c.c. of the juice, measured in a cup of that capacity, are taken, the workman has merely to divide the number of c.c.s of acid by 100 in order to arrive at the percentage of CaO or the alkalinity; for instance, 11·5 c.c. acid would correspond to an alkalinity of 0·115. Vivien's tube is another very simple and useful instrument for measuring alkalinity in juices. It consists of a thick test tube about 8 ins. long. The space below the zero mark is 10 c.c. and is filled with the juice. With phenolphthalein as an indicator, standard acid is run in until the colour disappears, and the degree of alkalinity is then read off directly on the graduations marked on the tube.

The percentage of CO_2 in furnace gases furnishes a test as to whether the combustion is being carried out satisfactorily. Some factories indulge in an apparatus called an Econograph, which is far too complicated to bear describing here. It is most fascinating to watch; it analyses and records, entirely automatically, the percentage of CO_2 in furnace gases, and, as it can be switched on to any individual furnace, the trouble, if any, can be immediately detected and remedied.[1]

No two factories appear to organise their daily routine work on the same plan. Some factories keep several chemists on the day shift as well as the night shift, whereas at others average samples are taken during the night shift and disposed of by the chemist before he begins his daily business. The following list of analyses will give a rough idea of what a chemist might be called upon to get through every 12 hours with one or two boys to help him, together with 50 or more beet analyses, much extra work in the laboratory as well as in the factory itself.

Fresh slices five times a day; exhausted slices every hour; pressed slices twice a day; raw juice, thin and thick juices three times a day; wash water, waste waters and lime cake frequently; massecuite, etc., average weekly samples and saturation gas twice a day. Several samples of each lot of the finished raw product are taken by professional samplers whenever ready to leave the factory, and then analysed.

Before concluding with a list of average analyses of certain products, definitions of two frequently occurring expressions might be added.

Rendement, is the number which indicates how much crystallised sugar can be won from raw sugar by the refining process. The method of calculating rendement is admitted to be unsatisfactory, and attempts have been made to substitute a better one, but so far without success. It is based on the assumption that during refining one part by weight of soluble salts (ash) contained in the raw sugar prevents five parts by weight of sugar from crystallising, and that this amount therefore is lost in the molasses. By way of illustration I quote actual figures obtained at the factory I worked at during the last campaign. The average polarisation of the first product raw sugar for the whole campaign was 94·65%, the average percentage of ash 1·263%, which multiplied by five gives 6·315. 94·65 minus 6·315 leaves 88·33, the rendement, according to the above definition. In other words, by refining 100 tons of first product raw sugar, 88·33 tons of pure sugar can be obtained.

Purity coefficient means the number which tells us the percentage of sugar in juices calculated on total solid matter. A thick juice, for example, with 48·8° Brix (*i.e.*, 48·8% total solids), and with 45·2 degrees polarisation, would have a purity coefficient of $\frac{45·2 \times 100}{48·8} = 92·6$. For reasons referred to under areometers, the purity coefficient obtained from Brix degrees is only apparent, as Brix degrees do not represent true total solids. Actual purity coefficients can only be obtained by determining the total solids chemically, by drying a weighed sample in an oven till constant.

A list of the chemical composition of some of the more important substances connected with raw sugar manufacture:—

Sugar beets	16—18% sugar
Raw juice (purity coefficient) ..	85—88
Thin juice: first saturation—	
Purity coefficient	86—89
Alkalinity	0·07—0·1
Thin juice: second saturation—	
Purity coefficient	87—90
Alkalinity	0·02—0·04
Thick juice: purity coefficient	88—92
Alkalinity	0·03—0·05
Saturation gas	30—35% CO_2
Lime cake	2—3% sugar
Fresh slices	16·2—16·5% sugar
Exhausted slices	0·1—0·2% sugar
Dried slices	2—5% sugar
,, ,, (Steffen)	30—38% sugar
Massecuite: purity coefficient	90—92
First product: rendement ..	87—89
Second product ,, ..	74—76
Molasses: purity coefficient ..	58—60

Preparations for Combating Diseases of Vine and Fruit Trees.—The Board of Trade are informed, through the Foreign Office, that an Order of the Minister of Commerce and Industry in Russia was published on June 22nd—July 5th, adding the following preparations to the duty free list:—Forty per cent. solution of formaldehyde, cupreous-arsenical salts, and bisulphide of carbon (*Board of Trade Journal*).

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[1] *Vide* "Automatic Analysis," by Charles A. Keane, *Chemical World*, Vol. 1, 4, 141, where the apparatus is described under the "Sarco" Combustion Recorder.

REVIEWS OF BOOKS.

"THE TECHNOLOGY OF BREAD-MAKING." By W. and W. C. Jago. SIMPKIN, MARSHALL, HAMILTON KENT & CO., LTD., 1911. Pages 908 + vi, including Index, numerous Illustrations. Price 21/- net.

This work is stated by the author to be a further development on the lines of his previous well-known books on the same subject. It is almost impossible to review it in any detail within the compass of this page. The mere sifting and collection of the matter contained in this work must have been a task of great magnitude.

A considerable space is taken up in considering the general nature of inorganic and organic compounds, and if we have any complaint to make, it is that this information might have been left to the more general text-books on this subject. This question must, however, remain a matter of policy, and left in most cases to the author. When we reach the chapters dealing with the proteins and carbohydrates, this possible objection does not apply, and in the next chapter dealing with enzymes and diastatic action, an extremely interesting account of the reactions of these little known and mysterious substances is given. This section includes work which has not been previously published, and will be read with interest by all those desiring a general knowledge of this subject which is destined to play such an important part in the chemistry of the future and extend its influence in many new directions.

In the same way, the chapters on fermentation, bacterial and putrefactive action, and technical researches on fermentation are equally worthy of study. The following sections, dealing with manufacture of yeasts and the structure and physiology of wheat grain and its chemical composition, are equally complete in their way. Flour is next treated in its many aspects, including the much vexed question of bleaching, and also that of the addition of "improvers."

The remaining chapters deal with the consideration of bakehouse design, commercial testing of wheats and flours, bread analysis, adulterations and additions.

This work is a veritable mine of information. It should be in the hands of all those interested in bread-making, and those who are directly or indirectly working in the allied and preliminary trades connected with it.

A reference to it will often save many a weary hour's search through the scattered literature connected with this subject, and this is, in our opinion, one of the chief recommendations to such a book. We can only congratulate the authors on producing a work of reference which cannot fail to remain a standard for many years to come.

"WATER ANALYSIS." By Herbert B. Stocks. CHARLES GRIFFIN & CO., LTD., London, 1912. Pages 136 + vi, including Index and Appendices. 8 Illustrations. Divided into 2 Parts. Price 4/6 net.

THIS book is primarily written for the use of public analysts, medical officers of health and students. The subject is treated under headings, and includes the physical examination as well as the chemical. It runs on the ordinary lines of such books, and includes microscopical, but not biological, examination. The section dealing with gases contained in solution seems to be one of the best. The illustrations are not altogether satisfactory, and the type of nitrometer mentioned on page 44 would hardly be met with in the form specified in an up-to-date laboratory. The section dealing with the recognition of deleterious metals, such as copper, arsenic, zinc, lead and iron, is quite satisfactory in its nature. The question of the action of water on lead is also treated in some detail.

The book serves its purpose in collecting, under one cover, particulars of methods involved in the analysis of water. It must, however, be remembered that under modern conditions bacterial examination must also be undertaken in the majority of cases.

Books Received.

"LUBRICATION AND LUBRICANTS," by Leonard Archbutt and R. Mountford Deeley. Charles Griffin & Co., Ltd., London, 1912. Third Edition. Pages 599 + xiv, including Index. Chapters XI., with 157 Illustrations and Numerous Tables. Price 25/- net.

"MODERN COPPER SMELTING," by Donald M. Levy. Charles Griffin & Co., Ltd., London, 1912. Pages 259 + vi, including Index. Divided into IX. Lectures, including 76 Illustrations, with Frontispiece. Price 10/6 net.

"THE LABORATORY BOOK OF MINERAL OIL TESTING," by J. A. Hicks. Charles Griffin & Co., Ltd., London, 1912. Second Edition. Pages 61 + x, including 32 Illustrations. Price 2/6 net.

"METHODS OF ANALYSING COAL AND COKE," by F. M. Stanton and A. C. Fielden. Technical Paper 8, Bureau of Mines, Washington, U.S.A. Pages 19, including 5 Illustrations.

"THE CHEMICAL CONSTITUTION OF THE PROTEINS," Part I. Edited by R. H. A. Plimmer and F. G. Hopkins. Longmans, Green & Co., London, 1912. Second Edition. Pages 188 + x, including Bibliography and Index. Divided into two Sections, including Diagrams. Price 5/6 net.

"METHODS OF SUGAR ANALYSIS AND ALLIED DETERMINATIONS," by Arthur Given. P. Blakiston's Son & Co., Philadelphia, 1912. Pages 75, including Index. Divided into thirteen sections with 8 Illustrations. Price $2.00.

Use of Specific Gravity Balls for Determining very Small Differences of Density.[1]

By Mr. T. H. BLAKESLEY.

THE present communication was made for the purpose of pointing out that the sensibility of specific gravity ball, was, as a matter of fact, vastly underrated by scientific men and the author quoted passages from Professor Balfour Stewart and Mr. Fownes which would tend to produce the belief that beyond the third decimal place specific gravity balls are not trustworthy. A variety of experiments was quoted which would indicate a sensibility a hundred times as great as this, and, indeed, that the error which might be expected in a properly conducted experiment would be of the order 5 in the sixth decimal place. The author has been in the habit for the last quarter of a century of employing specific gravity balls for the purpose of discriminating between the qualities of potable waters in respect of density and, therefore, of hardness, of testing the efficacy of softening processes, etc., for all of which the specific gravity ball is admirably suited. His process of observation differs from the ordinary rough-and-ready use in the fact that a thermometer of fairly open scale is employed to give the temperature at which a specific gravity ball is in equilibrium with a liquid which is being slowly warmed or cooled through that point of temperature. The error in such a temperature observation should not amount to more than three or four hundredths of 1° C.

If such a determination is made in distilled water at ordinary atmospheric temperatures it fixes the specific gravity of the ball at the temperature of equilibrium within four or five units in the *sixth* place of decimals. If a second observation with the same ball is made in a slightly heavier liquid, say, common tap-water, the temperature of equilibrium will be considerably higher, perhaps 2° or more, than in distilled water. By applying the coefficient of cubical expansion the density of the ball at the higher temperature can be obtained, and this is the density of the second specimen of water at the second temperature. Reference to a table of densities of distilled water will furnish its density at the higher temperature, and the difference between the two numbers will give what the author calls the density excess of the second liquid over distilled water at the higher of the two temperatures. This density excess is best quoted in parts in one million. For example, the density excess for a specimen of London water was found to be 290 at 17° C.

For a few degrees on either side of this value this number is sensibly constant, a fact of some value, as it enables one to employ four or five balls at the same time in one experiment.

One noteworthy result of experiments made through a long course of years is that simple glass balls tend to expand, especially in the years immediately succeeding their manufacture. The rise of the zero point of thermometers has led to the belief that glass contracts with age.

Mr. Blakesley then proceeded to explain the sort of apparatus which he thought might make the extreme sensibility of the specific gravity ball available for quickly detecting the infusion of fresh water in the ocean due to the presence of icebergs in the neighbourhood. This problem is one which cannot be decided without definite experiments made upon water specimens taken from the sea at various noted distances from icebergs, observing direction of wind and current at the times of taking the specimens.

PERSONAL AND OTHER NOTES.

ON Monday, July 8th, the Council of the Royal Society of Arts re-elected Lord Sanderson, G.C.B., K.C.M.G., chairman for the ensuing year.

Dr. E. J. Russell, at present Goldsmiths' Company's assistant, for soil investigations, has been appointed Director of the Rothamsted Experimental Station, in succession to Mr. A. D. Hall, F.R.S.

Sir Oliver Lodge, F.R.S., will deliver a memorial lecture in honour of Antoine Henry Becquerel, late honorary and foreign member of the Chemical Society, on October 17th, 1912.

Nature reports that "In view of the resignation of Professor Odling, of the Waynflete Professorship of Chemistry, which he has held for forty years, a committee has been appointed to collect subscriptions for the foundation of an 'Odling Scholarship' for the encouragement of Chemical Research. Subscriptions towards this memorial of Professor Odling's services will be received by Dr. H. B. Baker, F.R.S., Christ Church; Rev. G. B. Cronshaw, Queen's College; and Mr. H. B. Hartley, Balliol College."

Dr. S. J. M. Auld has been appointed to the Professorship of Agricultural Chemistry at University College, Reading.

The following officers have been elected at the general meeting of the Faraday Society held on July 2nd:—*President:* Dr. R. T. Glazebrook, F.R.S.; *Vice-Presidents:* Dr. G. T. Beilby, F.R.S., Mr. F. W. Harbord, Professor K. Birkeland, Sir Robert Hadfield, F.R.S., Professor Bertram Hopkinson, F.R.S., Mr. Alexander Siemens, and Professor James Walker, F.R.S.; *Treasurer:* Dr. F. Mollwo Perkin.

A New Method for the Determination of Ferrocyanides.—In a recent communication by H. E. Williams to the Society of Chemical Industry, the methods in general use for the estimation of ferrocyanides can be classed under two heads:—Titration of the ferrocyanide with a solution of a metallic salt; and decomposition of the ferrocyanide by suitable means into hydrocyanic acid. In the former class extreme care and long experience is required, and it is necessary that the titration be performed under conditions exactly similar to that of the standard, as any variation will generally lead to discordant results.

In the latter class the chief difficulty is the complete decomposition of the ferrocyanide into hydrocyanic acid by distillation with dilute acids—this difficulty has been overcome in the method worked out by Field—whereby the ferrocyanide is converted, first into mercuric cyanide by boiling with mercuric chloride, which on subsequent distillation with dilute acids yields the whole of its cyanogen as hydrocyanic acid, but as has been shown by Skerrow (*J. S. C. I.*, 31/3/10) and confirmed by the author, small losses occur in the preliminary boiling operations.

In the following process the losses above-mentioned are avoided and the process is both simple and accurate:—

Take 0·5 grains of ferrocyanide in 100 cc. of water and transfer to 250-300 cc. distilling flask, add 0·05-0·1 grains of cuprous chloride dissolved in a few drops of hydrochloric acid and finally add 25-30 cc. 4N/—sulphuric acid and distil through a condenser into caustic alkali solution: the cyanide solution so obtained is titrated with silver nitrate in the usual manner.

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[1] Read before the Physical Society.

NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER V.—(*Continued*).

IT is not possible on the present occasion to consider such matters in detail; or to more than touch upon examples in such procedure; but a few cases may be conveniently selected to give the student some indication as to their general nature.

A satisfactory example is perhaps that of the manufacture of hydrogen for commercial purposes. Preparation by the action of zinc has no longer any special interest. During a recent war it is said that this gas was prepared for balloon purposes from the action of concentrated caustic soda on aluminium shavings. Another process which has possibilities; and has been made use of, is the decomposition of calcium hydride. Hydrogen gas is passed into molten calcium in its preparation. Frank has proposed the method of passing water gas over calcium carbide with subsequent removal of oxides of carbon. The general method of preparation seems to be at present an electric one, but the action of steam on iron filings is said to have a future before it, especially when the resulting oxide is subsequently reduced by means of water gas, etc., and the process made a continuous one.

The difficulties of working these processes on a large scale cannot always be overcome in practice, and it is in such work that modern chemical engineering plays such an important part.

This example illustrates in a simple way the position a problem of this character may occupy at any intermediate stage in its development, and also when the investigation is finally completed in a satisfactory manner.

The work done at Mansfeld, in Germany, in the direction of the treatment of copper ores may also be taken as a typical example. Augustin, working some sixty years ago, found that when finely crushed copper *mattes* were bleached with sodium chloride the silver present was converted into chloride, and that this could be removed by solution in hot brine. Ziervogel subsequently found that by careful washing, coupled with a control of the temperature of the furnace, the silver could be converted into silver sulphate, which could then be washed out and recovered by precipitation on copper by the Augustin process. This process met with great success in Colorado, 2,770 tons of silver sulphate being recovered by this means at Argo alone. Another recent introduction at Mansfeld is the successful production of sulphuric acid from the converter gases produced in smelting the copper ore.

Again, in America, the Tenessee Copper Company are making 200,000 tons of tower acid per annum from the waste sulphur, while the Washoe Works of the Anaconda Company still discharges enough sulphur into the air to make 1,400,000 tons of acid per annum.

It has been claimed that with the exception of the apparatus used, metallurgical operations are essentially chemical in their nature. Many of the most important operations have to be conducted under supervision of trained chemists. It may be taken for granted, however, that in most cases of the treatment of ores, where any special difficulty is met with, that a very active co-operation of the chemist, miner, and metallurgist, is essential to success. Under such conditions ores can be worked, and give satisfactory profit, which would be "impossibles" in the absence of this mutual understanding and support.

In the past, many of the most promising processes connected with metallurgy were invented by the "practical men," and subsequently chemists were occupied in determining their nature and control. The chemist has now, however, established a more definite position, and from the commencement assumed the direction of affairs in such investigations. Thus we see the gradual supplanting of the empirical method by that of experiment. This is probably an inevitable result in the case of a long continued development in any industry working under modern conditions.

The part played by chemistry in connection with metallurgy is certainly a determining one. The processes of reduction and oxidation, selective solution, and many others of equal importance, all demand a definite knowledge of chemical procedure. In fact, the processes themselves are strictly chemical ones. The results sometimes obtained are astonishing. In the case of the extraction of gold from its ores by cyanide solution, a saving of a penny per lb. in the price of cyanide means a further reduction in working expenses of £70,000 in the Johannesburg district alone.

The treatment of silver ores by this process also offers the greatest possibilities. The bi-sulphite treatment for zinc ores also suggests very important developments. Many other examples will occur to the student. Among these, the results obtained from the study of the properties of metals and alloys suggest that, in certain directions, improvements which can hardly be guessed at will be made in industrial practice as a result of extended work in this direction.

The financial gain offered for successful investigation is often great. The commercial treatment of arsenic-colbalt-nickel ores, for instance, holds out great possibilities.

In electro-chemistry the advance has been phenomenal, and entirely new industries are being evolved. The original manufacture of calcium carbide has in its turn led to the production of cyanamides, which apart from their great value as fertilisers have, in their turn, given rise to the manufacture of ammonia, nitric acid and cyanides on an industrial scale. Developments in other directions have led to the direct fixation of nitric acid from the atmosphere. The production of calcium and sodium in large quantities, and many other substances also, has resulted from a study of the conditions of the electrical furnace as a means of inducing chemical action. This, in its turn, has led to the reduction, on a commercial scale, of metals like iron from its ores.

A definite study of the action of catalysis has led to results which are also destined to revolutionise many industries. Examples of this are already seen in the Deacon process of manufacturing nitric acid, and the Raschig method of making sulphuric acid. The field opened here is a wide one, and covers inorganic reactions as well as organic ones. The oxidation of naphthalene into phthalic acid, which has played so large a part in the manufacture of artificial indigo, is a case in point. Ostwald has pointed out (as quoted by Kennedy Duncan) that "if one considers that the acceleration of reactions by catalytic means, occurs without the expenditure of energy, and that in all technical work, including chemical, time is money, it is evident that the systematic use of catalysis may lead to far-reaching changes in technology." It is quite impossible, from our present knowledge, to suggest that any bounds can be set to future development in this direction, any more than in the case of electro-chemistry, or many others which might have been mentioned.

These few examples must serve to indicate the part which chemical investigation is playing in modern industry. It is remodelling procedure in industries of old standing; and, what is more important, supplying the necessary data for the establishment of a series of new ones. These owe their existence to experimental investigation, which is, in many cases, introducing into commerce new products, and processes, of great utility.

(*To be continued.*)

FINANCIAL NOTES.

At the annual meeting of the Mond Nickel Co., Ltd., the chairman announced the further expansion of their large works in South Wales, to deal with the increased demand for nickel and its alloys.

At the ordinary meeting of Coalite, Limited, held on July 4th, the chairman said there was working at Barking, under the supervision of the Eticoal Syndicate, a battery which was carbonising 35 tons of coal per day. Sir William Peat would have this battery carefully watched and checked for three months, and would issue a report on its working.

CLASSES IN CHEMICAL ENGINEERING.

The following questions set at the last examination in Chemical Engineering at the Battersea Polytechnic indicate the nature of the training being given there:—

(1) How would you design and make the joints in the following:—

(a) Condensing pipe-work for nitric acid.
(b) Pipe line for the transport of ammonia liquor.
(c) The dephlegmating column of a petrol still.

Give sketches to illustrate your answers, with dimensions when possible.

(2) A cast iron pipe 1 metre diameter metal, ·025 metre thick, connecting pyrites burners with a Glover tower suddenly cracks. What steps would you take to make a temporary repair? The temperature of the gases is 300° C., their velocity 1 metre per sec. and their heat capacity per mol. volume (22·32 litres) ·00836 cals. Find the drop in temperature per metre length of the pipe.

(3) Explain how you would design the pipework for the supply of a liquid at a given rate. A pipe, 2 ins. internal diameter, 40 metres long with 5 bends and a cock, is used for conveying water from a tank 9 metres above the point where it is required and delivers 18·5 c. metres per hour. How much glycerin at 10° and 30° C. would this pipe convey? Sketch your arrangement for maintaining the temperature in the latter case.

(4) Sketch a continuous or discontinuous drying plant to dry two tons of crystals per hour. The crystals are associated with 5 per cent. of water and are not hygroscopic. Make as many calculations relating to the plant as you can.

(5) Design an aluminium pan for crystallising in motion at a temperature of 60° C. At one operation 3,000 litres are reduced to 2,500 litres. Explain how you would determine (a) size of steam coil; (b) loss of heat by radiation and air conduction; (c) loss of heat by evaporation; (d) rate of evaporation and time of one complete operation.

(6) Sketch a hemispherical cast iron pan 2 metres diameter heated by a direct fire. Show the brickwork setting and the flues.

Explain how you would determine for a given output the size of pan, firegrate, flue and chimney.

How much water would a pan of the size given evaporate per hour?

(7) Design a condenser for a "wet" benzene still. 1,000 kilos. of benzene associated with 260 kilos. of steam are to be condensed per hour and cooled to 15° C. by means of cooling water at 10° C. Temperature of the vapours 69° C. Lat. heat of benzene at 69° C., 97·5 cals.

Explain how you might under a given pressure calculate approximately the proportion of associated water.

Treatment of Seaweed for Commercial Purposes.—The result of enquiries made by H.M. Minister of Christiania as to the treatment of seaweed for commercial purposes in Norway showed that seaweed is collected by the population of the West coast of Norway, from Lofoten in the north to Mandal in the south. After collection it is dried in the sun and burnt without too much heat, so that the iodine is not extracted. The price of the resultant ash is from ¾*d.* to 1½*d.* per kilogram.—*Board of Trade Journal.*

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By Emil Hatschek.

CHAPTER VII.—(*Continued*).

This absorption of water by elastic gels, and the volume changes which accompany it, are of enormous importance physiologically, and have accordingly been much investigated, in the first instance by botanists. The following are the salient features of the phenomenon: when an elastic gel is placed in water, the gel imbibes some of it and swells, but the total volume gel plus water decreases, *i.e.*, the process is accompanied by compression. This can be shown in a variety of ways, of which the following, used by the author, is perhaps the most striking. One gramme of the gel to be examined is placed in an ordinary pycnometer, the latter filled with water and the whole weighed. The pycnometer is then placed under water, and left till the gel has swelled to the full extent, taken out, dried and weighed again. The excess represents the amount of water which has entered the pycnometer owing to the reduction of the combined volume gel plus water. In one experiment, in which 1 gr. of gum tragacanth was used, in a 50 c.c. pycnometer, the increase in weight after one week amounted to 0·9 grammes of water, *i.e.*, 0·9 c.c. of water had entered, or almost 2% of the original volume. To obtain the same effect by compressing the water, a pressure of about 320 atmospheres would be necessary, and it follows at once that the process of swelling must be accompanied by the liberation of heat. This is, indeed, the case, and experiments have been made by many investigators to ascertain the amount of heat liberated during the swelling of gels. The following table gives the results obtained by Wiedemann and Luedeking, in gramme-calories per gramme of (dry) gel:—

Gel.	Gramme-Calories per gr. of gel.
Gelatine	5·7
Starch	6·6
Gum arabic	9·0
Gum tragacanth	10·3

While the total volume gel plus water decreases, the gel plus *imbibed* water increases, *i.e.*, the gel swells. The increase in volume can of course be measured only by confining the gel in such a way that the water has access to it, but is not implicated in the volume changes; for instance, by placing circular discs into a cylinder, which they fit exactly, and placing on top a weighted piston with numerous small perforations, through which water reaches the gel. Experiments with an apparatus of this description have been made by Reinke with the foliage of Laminaria, a seaweed, which behaves almost exactly like a gel. The table gives the pressure on the piston in atmospheres (kg. per sq. cm.) and the percentage increase in volume which the imbibition of water produces.

Pressure in Atm.	Percentage Increase of Volume.
41·2	16
31·2	23
21·2	35
11·2	89
7·2	97
3·2	205
1·2	318
1·0	330

This table also illustrates what large amounts of energy enter into the process. Even against the enormous pressure of over 42 atmospheres the gel still expands 16%, while with a pressure of 1 atmosphere the expansion amounts to 330%. In other words, 1 cubic centimetre of gel, if the swelling takes place in one dimension only (as in Reinke's apparatus) will lift 1 kilogramme 3·3 cm. Conversely it becomes clear what enormous pressures are necessary to remove the last traces of water from a gel, as the present example still retains 16% under a pressure of 42 atmospheres.

The various physical constants of gels—coefficient of thermal expansion, modulus of elasticity, the optical constants—are of great interest, as they differentiate the gels fairly sharply from both liquids and solids, but can only receive passing consideration here, as throwing light on their structure. If gels are not strained, they are isotropic, *i.e.*, they have the same coefficient of expansion, modulus of elasticity and refractive index in all directions. The coefficient of expansion in these circumstances is practically, and over a fair range, that of the liquid contained in the gel. If, however, a gelatine gel is stretched, it shows very remarkable anomalies; on rapid warming it *contracts*, while rapid cooling produces *expansion*. It is worth noting that india-rubber, stretched beyond a certain limit, shows exactly the same behaviour, namely a *negative* coefficient of expansion, a fact which had already been observed by Tyndall.

As regards the elastic properties, the most important point is that gels are deformed without change of volume; if, for instance, a gelatine cylinder is stretched, the cross section decreases in the same ratio in which the length increases, so that the product, *i.e.*, the volume, remains constant. Here, as in thermal expansion, the properties of the liquid portion of the gel are again seen to prevail.

Under stress, gels, which normally are isotropic, become doubly refracting, a property which they share with solids, such as glass. The change from simple to double refraction has been utilised to study their elastic properties, a subject into which it is not possible to enter here.

We have already touched on the question of gel structure at the beginning of the preceding chapter, where the view—based on a somewhat crude analogy—was expressed that gels were systems having a solid continuous phase, which enclosed or contained the liquid phase. The formation of reversible gels, like those of agar or gelatine, must therefore be accompanied by a change in the distribution of water, and we may naturally expect it to be affected by the presence of dissolved substances which modify this distribution, as explained in the chapter on emulsoids. This anticipation is found to be correct; salts like the citrates or sulphates produce more rigid gels, while iodides or thiocyanates retard or prevent gel formation.

As regards direct evidence of structure in gels, a considerable amount of material has been collected by Bütschli, who examined and photographed numerous examples at very high magnifications, in some instances over 2,000 diameters. The photographs very generally show a structure, which is interpreted as resembling a honeycomb, *i.e.*, it appears to consist of polyhedral cells. Such cells were, for instance, visible in van Bemmelen's silicic acid gels while they were turbid, but disappeared at the stage at which the gel became transparent (see the preceding chapter). The explanation given by Bütschli is that the cell walls are so thin, compared with the wave length of light, as to be invisible until a film of water is formed on them by further hydration.

The interpretation of Bütschli's results has, however, always offered great difficulties into which it is not possible to enter here, but which are inherent in the formation of microscopic images of periodic structures whose order of magnitude is that of the wave length of light. More recent investigations with the aid of the ultra-microscope, carried out by Zsigmondy and by Bachmann, appear to show that the honeycomb formation shown by Bütschli's photographs—whether real or due to optical defects—is not the ultimate structure of the gel, and that this latter is ultra- or even amicroscopic.

Nevertheless, the existence of a gel skeleton—that is, a continuous solid phase—can hardly be doubted, and is supported not only by the reasonings already referred to, but also largely by the phenomena of diffusion in gels. That dissolved substances diffused into or out of gels was known already to Thomas Graham, and is a fact familiar to every photographer, as the various processes of developing, fixing, toning, etc., are made possible only by the diffusion of the respective solutions into the gelatine gel containing the silver haloid. Graham found that sodium chloride diffused in gelatine with almost the same velocity as in water, but this has been shown to be the case only with fairly dilute gels. In concentrated gels the rate of diffusion is considerably slower than in liquids, and it can be varied by the addition of various substances to the gel. This has been shown particularly by Bechhold and Ziegler, who found that the addition of sodium sulphate, glucose, alcohol or glycerine retarded diffusion, while urea, iodides and chlorides accelerated it. These substances affect the distribution of water between the two phases, and therefore probably the relative volumes of the gel walls and the free liquid. It is probable that diffusion takes place almost exclusively in the latter, as appears from another experiment by Bechhold, in which a gelatine gel containing sodium chloride was covered with an aqueous solution of silver nitrate of equivalent concentration. In these circumstances an extremely thin layer of silver chloride is formed, which yet prevents any further diffusion. It can be shown that the gel skeleton remains unaltered, and that the silver chloride, which is sufficient to prevent further diffusion, is formed only in the interstices, or in other words, that diffusion only takes place in the latter, *i.e.*, the liquid phase.

This experiment leads us to the consideration of a further important section of our subject, that of reactions in gels. If a gel contains a substance in solution, and a second solution capable of reacting with the former is allowed to diffuse into it, reaction takes place, but exhibits a number of highly interesting peculiarities. The most striking one is that, in very many cases, the reaction does not proceed continuously, but that the product is deposited in strata separated by apparently clear intervals. The phenomenon was discovered by R. E. Liesegang (after whom it is generally called) in the following manner: A drop of silver nitrate solution was placed on a film of gelatine gel containing potassium bichromate. The silver bichromate which is formed by the reaction is not deposited in a continuous zone round the drop, but in concentric rings separated by apparently clear intervals. A similar structure is illustrated in Fig. 10; the test tubes were partly filled with a 1% agar gel containing calcium chloride, and on this were poured solutions of sodium carbonate, the ratio of their concentrations being 4 : 2 : 1. The calcium carbonate formed by the interaction is deposited in a number of strata, and the effect of the different concentration of sodium carbonate is strikingly shown.

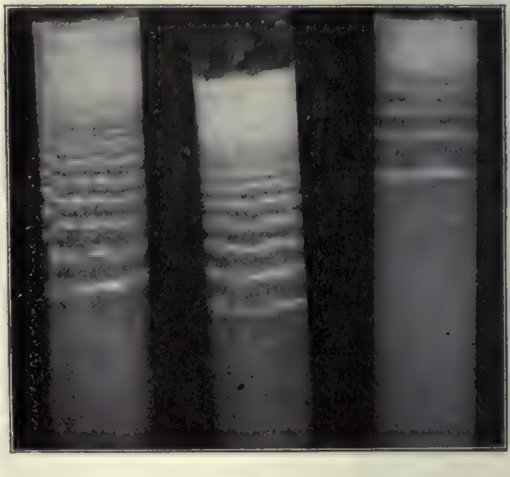

FIG. 10.

No satisfactory explanation of these stratifications can be given at present, though a great number of factors which may contribute to their formation have been pointed out by various observers. This point is one which may be expected to receive increased attention in the future.

(*To be continued.*)

Applications of the Law of Mass Action to some of the Reactions of the Tanning Process.[1]

By EDMUND STIASNY.

A COMPLETE understanding of the reactions involved in tanning is in many cases possible only on the basis of physico-chemical laws. The study of the plumping and falling phenomena and the colloid-chemical behaviour of the hide-proteins and of the tannins are examples of the more complex of these problems, the great difficulties of which can only be solved very gradually. There are, however, some simpler processes, the explanation of which can be given by applying the mass rule, which at the same time enables valuable conclusions to be drawn. The deliming of limed hides and the neutralisation of chrome leather are processes of this kind and are now discussed.

1. DELIMING OF HIDES.

Limed hides after mechanical unhairing and fleshing are washed several times with water, though thereby only a part of the lime can be removed. The thorough deliming is done by means of acids and often completed by bates. As a rule when deliming with acid it is necessary to remove from 0·4 % to ·1 % CaO (per cent. of the pelt weight). This deliming requires much attention, as an excess of acid must be carefully avoided so as not to produce an acid plumping. The danger of an excess of acid is the greater the stronger the acid is, and therefore most tanners prefer the weak organic acids (lactic acid, acetic acid, formic acid, and more recently butyric acid) to the strong inorganic acids (hydrochloric acid). The most favourable action would in all probability be obtained by an acid which is so weak that it has no swelling effect at all, and therefore could be used in excess. H. R. Procter has shown in his valuable work on acid swelling that the limit of swelling power lies at a concentration of the actual hydrions of $C_{\dot{H}} = 10^{-5}$ to 10^{-4}. This important discovery forms the basis of the following deliberations. An acid which, when diluted for use, shows a lower hydrion concentration than $5 \cdot 10^{-5}$, and which is present in sufficient quantity for complete deliming, will not do any harm if used in excess, and will produce an absolutely lime-free hide. Assuming that the deliming is done in the paddle with a quantity of solution four or five times the pelt weight, and that the amount of lime present in the hide amounts to 0·6 per cent. CaO, then this would call for the use of about a $\frac{1}{20}$N acid, for

$$\frac{600}{28 \times 400} = 0{\cdot}054.$$

The strength of an acid is given by its dissociation constant. Therefore the magnitude of the dissociation constant must first be determined for any acid which in $\frac{1}{20}$N-solution has a hydrion concentration of about 10^{-5}. According to the mass rule we have $K . C_{HX} = C_{\dot{H}} . C_{x'} \doteq C_{\dot{H}}^{2}$, in which K is the dissociation constant, C_{HX} the concentration of the undissociated acid molecules and $C_{\dot{H}}$ the hydrion concentration. As $C_{\dot{H}} = 10^{-5}$, and C_{HX} for a very weak $\frac{1}{20}$N-acid is about 0·05, so we have for an acid which should show the above action, $K = \frac{C_{\dot{H}}^{2}}{C_{HX}} = \frac{10^{-10}}{0{\cdot}05} = 2 \cdot 10^{-9}$.

Any acid, which shows a somewhat low dissociation constant, can be used for deliming purposes, if it fulfils the following conditions. It must form a soluble lime salt; it must be non-poisonous, odourless, and low in cost. The only acid which fulfils these conditions and at the same time has a dissociation constant of 10^{-10} to 10^{-8} is boric acid. But the choice of acids can be much increased, as it is possible to produce a deliming solution having the desired properties, by mixing the solution of a suitable acid whose dissociation constant lies between 10^{-5} and 10^{-4}, with an equivalent amount of one of its soluble salts. Thereby the hydrion concentration is reduced below that necessary to produce a plumping action. According to the mass rule we have the equation $K, C_{HX} = C_{\dot{H}} . C_{X'}$, and from that $C_{\dot{H}} = \frac{K . C_{HX}}{C_{X}'}$ in which K, C_{HX} and $C_{\dot{H}}$ have the above-mentioned meaning and C_{X}' represents the concentration of the acid radical-ions. As the C_{HX} of a weak $\frac{1}{20}$N-acid is about 0·05 and C_{X}' of a $\frac{1}{20}$N-salt solution is also about 0·05, we get $C_{\dot{H}} = K$. In other words, the hydrion concentration of an equivalent mixture of a weak acid and its salt is equal to the dissociation constant of the acid.[2]

Therefore, for deliming purposes, any harmless, cheap acid can be taken which forms soluble lime salts and whose dissociation constant is not materially above 10^{-5}, and this acid must then be mixed with the equivalent amount of one of its salts or half of the acid can be neutralised, in order to obtain a deliming solution answering all conditions.

Such a solution is neutral to methyl orange and gives when titrated with phenolphthalein the amount of potential hydrions for deliming. These principles can be applied in practice by placing in a paddle, per 100 kilos. of the white weight, 1·28 kilos. acetic acid, and 1·76 kilos. sodium acetate with 400 litres of water,[3] and paddling the hides in this solution until a cross-section shows no lime (no reddening with phenolphthalein). For the stated amounts, the percentage of lime in the wet pelt is assumed as 0·6 per cent. The used bath can be brought back with little expense to its original state if sufficient oxalic acid is added to precipitate the dissolved lime.[4] This is carried out in a vat and the precipitated lime allowed to settle out, after which the supernatant solution containing the original proportion of acid to salt, is returned to the paddle. It is only necessary to add enough of the fresh acid and salt solution to replace the unavoidable loss in the operation. An excess of oxalic acid must be avoided, and the deliming solution should always be neutral to methyl orange.

Instead of acetic acid and sodium acetate, butyric acid and sodium butyrate may be used. With this material it would be more economical to prepare the butyrate by neutralisation of the butyric acid. The solution is prepared by dissolving 3 kilos. of crystallised soda in hot water and adding (while stirring) to the hot and somewhat concentrated solution 3·76 kilos. of butyric acid, continuing stirring until the carbonic acid gas has escaped.[5] The mixture of butyric acid and sodium butyrate is then placed in the paddle.

Instead of the soda salt, an ammonium salt may be prepared which would produce a preliminary bating. A mixture of butyric acid (or any other organic acid) and its salt may also be prepared by gradually deliming a pack of limed skins with successive small portions of butyric acid, adding the portions of acid when the solution reacts alkaline to phenolphthalein. The last portion of the acid, even after complete neutralisation, will not produce any plumping effect, as considerable amounts of the soluble lime salt formed at first repress the dissociation of this excess of acid. The bath for the next pack is prepared by running off one-fourth of the used bath and adding as much acid.

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[1] Read at the Washington convention of the A. L. C. A., Dec., 1911

[2] See Ostwald: Grundriss der allgemeinen, Chemie, 1909, p. 461.

[3] For 100 lbs. hide, 1 lb. 4 ozs. acetic acid, 1 lb. 12 ozs. sodium acetate, 40 gallons water.

[4] The application of oxalic acid for liberating organic acids combined with lime was first proposed and applied by H. R. Procter for the purification of handler liquors

[5] Should carbonic acid remain dissolved in the water, it would combine with the lime of the hide to insoluble calcium carbonate, which is not soluble in the deliming mixture and which would cause defects in the finished leather.

By this working system the amount of calcium butyrate which will be present in the bath after repeated use will be four times the salt produced by deliming one pack. Or if $\frac{1}{n}$ be the portion of the paddle liquor removed after each pack, the amount of calcium butyrate present will finally rise to n times the amount which is produced by deliming one pack. Hence the hydrion concentration of such a bath will come down to $C_H = \frac{K}{n}$, where K is the dissociation constant of the acid.

One per cent. of magnesium carbonate (on the pelt weight)[6] is added to the old bate as a clearing bath.

2. Neutralisation of Chrome Leather.

Chrome leather after thoroughly washing with water is treated with a neutralising agent in order to remove any free acid present. In this neutralisation, it is essential that no free acid remain, and also that no excess of alkali be used, for over-neutralisation injuriously affects the appearance and compactness of the finished leather. It may be due to the alkali having a detrimental action on the leather fibre, or it may be that the basic chrome salts are converted into chromium hydroxide, which is not to be desired. Therefore we have, when neutralising chrome leather, a case similar to the deliming of hides, requiring carefully regulated neutralisation.

The question then arises, can we also determine here the limit of the hydroxyl-ion concentration, below which a weak alkali, even in excess, will not exert a detrimental action? Such a limit, after many experiments, seems to lie at a hydroxyl-ion concentration of about 10^{-5}. If an alkali is selected which in $\frac{1}{10}$N-solution (the usual neutralising solutions are about $\frac{1}{10}$N) has no higher hydroxyl-ion concentration, and is cheap, harmless, odourless and forms soluble sulphates and chlorides, then this substance may be used in excess without fear of getting bad secondary actions on complete neutralisation. Such an alkali must possess a dissociation constant of K = about 10^{-9}, for $K = \frac{C^2_{OH'}}{C_{MeOH}} = \frac{10^{-10}}{0{\cdot}1} = 10^{-9}$, in which $C_{OH'}$ represents the hydroxyl-ion concentration (assuming this to be 10^{-5}) and C_{MeOH} is the concentration of the unionised alkali molecules. An alkali fulfilling all these conditions is not easily found, but such a neutralising solution can be readily prepared by mixing equivalent quantities of ammonia and ammonium sulphate, for the hydroxyl-ion concentration of such a solution yields according to the mass rule the desired value of $C_{OH'} = \frac{K \times C_{NH_4OH'}}{C_{NH_4}} = \frac{2{\cdot}3 \times 10^{-5} \times 0{\cdot}1}{0{\cdot}1} = 2{\cdot}3 \times 10^{-5}$, in which K represents the dissociation constant of ammonia ($2{\cdot}3 \times 10^{-5}$), $C_{NH_4OH'}$ the concentration of unionised ammonia molecules (which $\frac{1}{10}$N-solution is about 0·1), and C_{NH_4} the concentration of ammonia ions (which last, in $\frac{1}{10}$N-ammonium salt solution, is also about 0·1).

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[6] Magnesium carbonate is preferable to calcium carbonate on account of its solubility.

COMMERCIAL AND GENERAL NOTES.

The Utilisation of Waste Liquor from Starch Factories.

Interesting experiments have recently been conducted in France with the object of discovering suitable methods for the utilisation of waste waters from starch factories. Although they are very dilute, containing as a rule something over 99% of water, there is a certain loss of fertilising matter in the waste waters, the dried residue of which contains 6·56% of nitrogen, 2·78% of phosphoric acid, and 13·64% of potash with 2·11% of lime.

The agricultural use of the waste is considered highly desirable, but with such dilute solutions as are now produced, is not practicable except for small factories. A new method of extracting the juice of the potatoes by means of presses before washing for the preparation of starch is recommended, and it is believed that this will furnish a concentrated extract which can be profitably handled as a fertiliser. Analysis of a juice obtained in this way showed dry matter 5·03%, nitrogen 0·35%, phosphoric acid 0·12%, potash 0·65%, and lime 0·01%.

It is estimated that by this method 1,000 lbs. of potatoes may be made to yield as a bye-product fertilising material worth 2*s.* 5*d.*

Canada as a Market for Insecticides.

The trade in insecticides in different parts of Canada has become of great interest to manufacturers and shippers of this commodity. Great quantities of insecticides are used for spraying orchards and also wheat for the prevention of smut. Formaldehyde is chiefly used for the latter, part of which is manufactured in Canada and some is imported from Germany.

For orchards farmers usually make their material for first spraying by boiling to a liquid sulphur and lime, which can be made in great quantities quite cheaply, but prepared products are on the market, for which the dealer pays $5—6 per barrel. One American company has a product which it pushes in Ontario. The largest producer of these commodities is a chemical, iron and lumber company of Toronto, which has nine branches established over the Dominion. It manufactures a large number of bye-products in connection with the lumber business, among which are insecticides.

Arsenate of lead is used extensively for second spraying, which costs the dealer 7·12 cents per lb. A combination is also used, consisting of 4 lbs. of sulphate of copper, 4 lbs. of lime, and 4 ozs. of paris green, producing about 40 gallons of material.

Appeal to the Austrian Government for New Laboratories.

The association of Austrian chemists has started an agitation for the purpose of improving the conditions pertaining to the laboratories of the Vienna High School. In a petition to the Educational Ministry, signed by most of the leading Austrian chemists, the association refers to the unsatisfactory conditions in the High School laboratories. "To make these laboratories up-to-date," the memorandum to the Government says, "is urgently required by all branches of social economy depending in one way or another on chemists. It is a regrettable fact that the laboratories do not serve in the least the purpose for which they are intended. The lack of space is so great that the rooms do not even conform to the most elementary hygienic requirements. Insufficient room prevents the proper organisation of the teaching and the development of laboratory work in accordance with the requirements of science and technology. The association earnestly hopes, therefore, that the Government will start immediately with the new buildings for the chemical laboratories and thereby put a stop to the humiliating conditions prevailing in the present laboratories."

Ammonia Evaporation and Transformation in Soils.

The lower fertilising efficiency of ammonium sulphate as compared with sodium nitrate has been ascribed to various reasons, including slowness of nitrification, fixation of nitrogen in organic forms, and evaporation of ammonia. The *Zentralblatt für Landwirtschaftliche Chemie* contained in a recent number an interesting article on this subject by I. von Wlodeck, in which the writer reviews the work of other investigators and reports experiments on soils in sunken cylinders to determine the loss and transformation of ammonia from soils, containing varying amounts of lime, silt and clay. In the course of these experiments varying applications of ammonium sulphate, either alone or in combination with superphosphate, were made.

The loss of ammonia by evaporation, when the ammonium sulphate was used, under conditions as nearly natural as possible, was very small. With a high lime content of the soil and heavy applications of ammonium sulphate the loss was larger. There was little or no loss where a mixture of ammonium sulphate and superphosphate was used. Deep application of the ammonium sulphate greatly reduced the loss of ammonia.

The results of the observations on fixation of the ammonia in organic forms were not entirely conclusive, but indicated that fixation in case of a loam soil was practically the same whether the ammonium sulphate was used alone or mixed with superphosphate. On a light soil, however, the superphosphate appeared to increase nitrogen fixation. The addition of superphosphate apparently did not effect nitrification.

Celebration of a Great French Chemist.

The Association of Textile Chemists in France (Association Générale des Chimistes de l'Industrie Textile) intends to arrange some interesting festivities next year in honour of Maurice Prud'homme. The occasion will be the 40th anniversary of his association with chemical research work. It is proposed to issue a medal with the portrait of the great scientist and to publish his collected works.

Candelilla Wax.

One of the "coming products," the utilisation of which is likely to attain considerable dimensions, is the wax obtained from a plant *euphorbia cerifera*, commonly called candelilla wax. The plant is of Mexican origin, but it thrives in different parts of the world, and the introduction of it in Antigua, St. Kitts and Montserrat has been very successful. In Montery the supply of the candelilla plant is practically inexhaustible, and there are now four factories at this place extracting the wax which serves as a substitute for carnauba wax.

It can be extracted by cutting up the plant into small pieces and either wrapping in wire cloth and immersing in boiling water, when the melted wax rises to the surface and can be skimmed off, or by subjecting the mass to live steam in order to melt the wax. This can then be separated from the condensed water. The impure wax so obtained is purified by re-melting and filtering through charcoal mixed with iron filings; it then varies in colour from greenish yellow to almost chocolate black, but can be partially bleached to such an extent as to compete with carnauba wax. The substitute is not so hard and brittle as the real wax. The composition varies considerably, as it is affected by the age of the plants, the region where they grow, and the time of the year they are collected. Its physical and technical properties have not yet been fully recorded.

Formation of a Norwegian Company for the Manufacture of Carborundum.

"Arendals Smelteverk" is the name of a new Norwegian concern which has recently been formed at Arendal for the manufacture of carborundum. The management of the factory will be taken over by a German gentleman, Mr. Moyat, who has held similar positions in Germany, and who sold to the new company the rights and patents of manufacture for 200,000 kr. in shares. The remainder of the capital has been obtained from Norwegian and German capitalists. At first the company is going to work with 3,000 H.P. obtained from the Aktiengesellschaft Arendals Fossekompagnie at 38 kr. per H.P. Later on the power is to be increased to 6,000 or 9,000 H.P. The product will be sold to a prominent German firm. Among the directors of the company are several important names, such as the well-known engineer Mr. Eyde.

Germany's Chemical Industry and its Products Abroad.

No other branch of industry in the Fatherland has been more successful in establishing foreign trade than the manufacture of chemicals, more particularly the department for colours and varnishes. Nearly every one of the larger German paint and varnish firms has customers abroad, and many of them have opened branch houses in the most important countries in order to evade the high protective duties on imported goods. The most favoured country for the establishing of branch factories is Russia. Moscow is considered a very suitable place for this purpose on account of its central position and close vicinity to many large textile concerns. Some of the best known German paint and colour works, such as Farbwerke vorm. Meister, Lucius and Brüning, are there established with a capital of 2,500,000 rubles, the Anilinfabrik with 2 million rubles, and the Chemische Fabrik auf Aktien vorm. Schering with 600,000 rubles. In other parts of Russia several other large German concerns have branch establishments which enable them to compete successfully with the home manufacturers as well as the imported goods. One of the most recent enterprises is a new company which the well-known firm of Farbenfabriken vorm. Fried. Bayer & Co. at Elberfeld has formed. The headquarters of this will be in Moscow, and there will be branch establishments in St. Petersburg, Iwanowo, Lodz and Kieff. The Aktien-Gesellschaft Farbwerke in Moscow made last year a net profit of 223,205 rubles and distributed a dividend of 6% to its shareholders.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

12207/11. G. MEUNIER, Raab, Hungary. **Treating Distillery Wash.** Dated, under International Convention, as 21 May, 1910.

The invention relates to a method of treating distillery wash for the purpose of obtaining the glycerin contained therein, together with succinic acid and alkali salts. The method of treating distillery wash consists in mixing it with cellulose which has been partially or completely carbonised and freed from incrusting substances, preferably wood cellulose. It is then dried and the glycerin, together with the succinic acid, in the wash extracted by means of one or more solvents for these substances, if desired by the aid of osmosis or pressure. The residual mass resulting from the above treatment has considerable heating value, and is capable of being moulded into briquettes, by the burning of which alkali salts or crude pearl ash can be obtained. (3 claims.)

12457/11. T. A. BAYLISS, Warwick, and B. G. CLARK, London. **Zinc Alloys.** 23 May, 1911.

According to this invention, a malleable alloy of zinc, aluminium and lead is produced in which the ingredients are present in the finished alloy in proportions between the limits of:—zinc, 99·1%—99·9%; aluminium, 0·001%—0·9%; and lead, 0·01%—0·9%. The method of preparing the alloy consists in heating together the zinc and lead to bring them into a molten condition, then adding aluminium in a solid or molten state, either pure or in the alloyed form, to make the composition required, adding a flux and allowing the alloy to cool and set. Afterwards it is rolled and annealed. (4 claims.)

13442/11. O. SILBERRAD, London. **Explosive.** 6 June, 1911.

This blasting explosive contains 60—70 parts of potassium perchlorate and/or ammonium perchlorate or both, 12—13 parts of mononitrobenzene, mononitrotoluene, or a mixture thereof, 6—7 parts of dinitrotoluene, 6—7 parts of mononitronaphthaline, 5—6 parts of wood meal, and 0·5—2·5 parts of soluble nitrocellulose. The various nitro and dinitro compounds are incorporated together, the soluble nitrocellulose added thereto and the mixture warmed until gelatinisation is complete. The wood meal and oxidising substance are then incorporated in the mass, when the substance may be pressed into cartridges. (3 claims.)

13443/11. O. SILBERRAD, London. **Explosive.** 6 June, 1911.

The blasting explosive described in this specification differs from that described in the abstract of specification No. 13442, above, in that the applicant employs 60—70 parts of potassium chlorate in lieu of 60—70 parts of potassium and/or ammonium perchlorate, or both. (3 claims.)

16000/11. H. PETERS and H. W. CULLUM, London. **Cellulose Compounds.** 10 July, 1911.

According to this invention, cellulose is treated for some time with dichlorhydrin or epichlorhydrin and palmitic acid, or with an oil or glycerin with or without palmitic oil. After cooling the mass of cellulose and removing the adherent dichlorhydrin or other substance, it is treated with a solution of formic acid and a diluent, such as methylated spirit, containing palmitic acid if palmitic acid has not been used in the first treatment. The resulting mass is subjected to an acetylising bath and the product is then separated and neutralised. (3 claims.)

24259/11. THE BRITISH THOMSON HOUSTON CO., LTD., London. **Purification of Asbestos.** 1 November, 1911.

The invention relates to a method of purifying asbestos, and consists in subjecting commercial asbestos containing a difficultly soluble metallic oxide, such as magnetite, to the action of a solution of oxalic acid, and then washing with water. (3 claims.)

28404/11. D. HELBIG, Wallis, Switzerland. **Oxygen.** Dated, under International Convention, as 17 December, 1910.

The process of producing oxygen, according to this invention, is characterised by the fact that mixtures of salts of per-sulphuric acid (more particularly the persulphates of potassium and sodium), and oxides or peroxides (more particularly of the alkali and alkaline earth metals), or hydrates thereof, with or without inert admixtures, are caused to react by a suitable liquid, for example water, or by heating or the like. By this process free oxygen and a sulphate or mixture of sulphates of the metal or metals present are obtained. (2 claims.)

2881/12. SOUTHALL BROTHERS AND BARCLAY, LTD., and C. S. ROY, Birmingham. **Glycerophosphates.** 5 February, 1912.

A process for the production of the acid calcium, barium, strontium, iron, manganese, magnesium, aluminium, potassium, lithium and mercury salts of glycerophosphoric acid consists, according to this invention, in heating the oxides, hydroxides, carbonates or neutral or acid phosphates of calcium, barium, strontium, iron, manganese, magnesium, potassium and lithium, and aluminium and mercury oxides or phosphates with aqueous syrupy phosphoric acid and heating the mixture so obtained with glycerin under reduced pressure. (4 claims.)

6993/12. ACTIEN GESELLSCHAFT FUR ANILIN-FABRIKATION, Treptow. **Red Mono-azo-dyestuff.** Dated, under the International Convention, as 17 January, 1912.

There has been described the manufacture of a blue-red dyestuff, suitable for the preparation of colour lakes, by combination of diazotised 3 : 4 : 6-trichloraniline with 2-naphthol 3 : 6-disulphonic acid. According to the present invention, by substituting for the 3 : 4 : 6-trichloraniline, the isomeric 3 : 4 : 5-trichloraniline, there is also obtained a bluish-red dyestuff. (2 claims.)

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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THE NEW CHEMISTRY.

INDICATIONS point to possible developments on an extended scale of a new and more intimate phase in the relationship between the science of chemistry and general finance. This is a matter which naturally requires careful watching, if only from the fact that it is concerned with the part the chemist is destined to play in the general development of industry. This new development can be a satisfactory one only when certain necessary conditions are realised.

It must be remembered, if the chemist is to come out into the searching light of the prospectus world, taking a more direct part in what may be legitimately termed the advertising side of finance, that corresponding safeguards will have to be devised to ensure in the event of any non-success, on general lines, that the burden of failure will not fall unduly on the chemist or chemical engineer.

There is an increasing tendency to use the authority of scientific knowledge and attainment in the process of company promoting. The growing influence of science on the British public is based apparently on the reports of developments on similar lines, which filter through from the Continent. This can only be regarded as satisfactory when such an extension rests on a sound basis. It is necessary to ensure that a high standard of knowledge and practice shall apply on the scientific side, and that the scheme in general shall be based on the results of practical experience. This condition should be easily met. If not, the result will be disastrous.

In the event of this not being achieved—for reasons unconnected with the scientific side of the question—an unfortunate state of affairs may arise as between the scientific world and the general public. This could not fail to have an adverse influence on the prestige of the former. Everything must be done to prevent such a contingency, and the standard of the scientific adviser and his experience must be of such a nature that this position cannot become a general one.

This association, however satisfactory it may be, should not be allowed to modify the ordinary and reasonable safeguards which are generally adopted in company finance. If the conditions are to be successfully met, it will be necessary for those on the scientific side to have at their command a definite knowledge of company practice, and also, in some way, a voice in the conditions of such issues. Or, as an alternative, to be properly advised in such matters by those who have the required experience. The delivery of a report, or opinion, does not necessarily discharge the liability in such cases.

Reasonable precautions must be taken in cases where a prospectus is mainly issued on the basis of a report, that the general conditions of the issue are also satisfactory. The matter must be considered from a practical business point of view, for shareholders are not anxious to endow research to the entire exclusion of dividends. With such reservations a satisfactory result may be looked for in this new development, which may in its essence favourably influence the conditions of future industrial progress. The position carries its corresponding responsibilities which must, in effect, apply to details other than those entailed in the conduct of research, or general investigation.

The chemist must on no account be exploited for the creation of new schemes which are unsound from a financial point of view. Too much depends upon the success of this new development to risk the chance of any general failure in this respect.

With this additional publicity must come a corresponding responsibility. This is the point at issue. It is one which will have to be considered in some detail in any future developments. This matter may even entail a special organisation to deal with it, as the future position of the chemist in industry may be materially influenced by this new condition of affairs. The larger question of the relationship between science generally and the public, is also involved, and every possible care must be exercised by all parties concerned, as their action may have a general influence for good or evil.

Public Schools.

The recent discussion on the training imparted at these Institutions has been long and not altogether conclusive.

In some quarters the question whether a satisfactory education can be obtained by the average boy at such institutions is still considered to be an open one.

A recent article on this subject by Edmund Bosanquet has in one respect a certain interest. Speaking as an old Etonian he holds that, "It is in these days an appalling handicap for every boy who is educated at a public school." Speaking particularly of Eton, he says :—

> "Boys who go there have an excellent time, a 'top-hole' time, if they are 'good fellows' in the conventional sense of the word. They can make plenty of charming friends and play any amount of fine, healthy games. Also they can—we are dealing with the *average* boy—acquire a smattering of all sorts of subjects supposed to be educative. Classics are imbibed with much unwillingness and the use of cribs, and forgotten as quickly as possible. Mathematics are driven into every skull by the same means. French and German are excuses for 'slacking,' and science, chemistry, and the like for the indulgence of an interesting hobby—all where the average boy is concerned. There is practically no attempt at individual training. The whole thing is a system into which round boys, and square boys, and triangular boys, and boys of no symmetrical figure must all fit or be damned."

This writer makes the further statement that "I do not think that any old Etonian of my acquaintance, and age, can deny that this is accurate as applied to *the average boy*, and the average boy is the person to consider in these questions. One leaves Eton at about eighteen and then, in these days, is embarked on the sea of life. What is the equipment for the voyage? I think it has been set out, and its value can be estimated. . . It is considered to be first-class for eldest sons of rich men, even younger sons of very rich men, but the average boy is neither of these."

Granted that it *is* necessary for the average boy to assimilate one or two dead languages on the score of general training, a system which insists on such teaching must necessarily be of a highly scientific order. Does the rest of the training conform to this view? This is not seemingly so. It is stated that the pupils have in addition to a more or less superficial knowledge of dead languages, an equally unsatisfactory knowledge of certain general subjects. If this is so the training is indeed unsatisfactory. It is held in such quarters to include the following items: The rudiments of French and German grammar, taught by Englishmen. Dead languages taught on a cramming system to all, for the benefit of the few who "go up" to the Universities.

It is said to be based on certain vested interests in the University in a purely classical system, and similar interests in the Schools. And the boys—what of them? "The raw material of a vicious system" says one. "Subjects of a training based on the formation of character, in an institution which is the place of selection for friends in after life," says another.

Future Conditions.

One thing is certain. These boys must in the ordinary sequence of events act as leaders in a world which will be largely represented by industry in some shape or form. Also, that they will have to stand up against the trained industrialists found elsewhere. Mr. Edmund Bosanquet, for one, does not think that they are receiving an adequate training. He says :—

> "Casting the mind over various school contemporaries with whom one is still acquainted, what does one find? Personally I know, in my own neighbourhood, a stock-jobber, an architect, a solicitor, a land agent, a stockbroker, a journalist, a motor-car seller and agent, an engineer on a railway—all of them my contemporaries and what one may term average. What do they say of their Eton education? One and all avow that it was useless to them in their professions.
>
> "It appears to me from the above statements of fact, which are scarcely arguable, that there is something the matter with the state of Eton and other public schools. Something very serious indeed, clogging the pores, sapping the vitality of the young of the 'classes.'
>
> "It might perhaps be likened to ivy which supports an ancient tower, which would be better down than suffered for the sake of its old-world beauty and traditional value. Take away the ivy of tradition and custom, expose the poor old structure to the cruel, naked light of common sense, and what will happen? Either the old fabric must be restored or it must be allowed to crumble into the dust of the past, among the stage-coaches and the crinolines."

The suggestion is made that the public schools can only justify their existence if they conform to certain conditions.

> "With all humility, I would suggest that practical education in those subjects which will at least enable *the average boy* to obtain work might meet the case, shore up the old walls, and reface the crumbling bricks.
>
> "Farming, book-keeping, shorthand, typing, the many branches of engineering, finance, journalism, literature, riding and horse-breeding, management of land, of money, the rudiments of law or medicine, or military life and science, to mention only a few of the subjects an average knowledge of which would qualify *an average boy* for employment, should be easy enough to teach—a good deal easier than Greek or English-French or compulsory trigonometry. By all means let boys *learn* foreign languages, but not as taught at Eton in this twentieth century.
>
> "But, above all, teach the boy what he wants to learn. Let him follow his inclinations and cultivate his own peculiar gifts."

This picture of the system adopted in our leading school is not a particularly satisfactory one. Professor Perry also deals with the subject in a recent address reported in this number. We seem as a nation to be constantly in the position of having to face an exposure of some nature or other connected with our educational system.

The Permanent "Growth" of Cast Irons after repeated Heatings: Its Causes and possible Remedies.

By Professor H. C. H. Carpenter, University of Manchester.

Part I.—*Causes.*

On account of its cheapness as compared with steel in any of its manifold varieties, cast iron finds many industrial applications. In some of these it is subjected to a process of alternate heating and cooling, as a result of which it is frequently found to undergo a permanent swelling or growth. Such growths are manifested at temperatures as low as those of superheated steam. They are even more evident when a temperature of 700° C. is exceeded, and between 800° and 900° C. they are of considerable magnitude. With this growth is always associated a deterioration of mechanical properties, until in extreme cases the iron entirely loses the properties of a metal. It is therefore an important practical problem to ascertain the cause of this permanent growth and if possible to find a remedy.

It is not perhaps generally known how varied are the uses of cast iron in cases where alternate heating and cooling is part of the normal procedure. Such applications may be grouped under three main heads :—

(1) Where the iron is in contact with hot liquids. Instances of this are ingot moulds for steel castings, flat ingot moulds for glass, and file-hardening pots containing molten lead. In such cases the temperatures the iron has to withstand may be excessively high.

(2) Where the iron is in contact with hot gases. Instances of this are very numerous, *e.g.*, the grate bars of mechanical stokers, the grids of muffle furnaces, annealing furnaces, gas producers, the baffle plates in heating stoves, and the stove pipes of hot blast stoves. A special case of this type is the use of cast iron cylinder rolls, where the gas in contact with the iron is air.

(3) Where the iron has to stand steam superheats, as in the form of turbine casings, high-pressure steam valves, and piston rings.

In some of the above cases the growths are of considerable magnitude, figures of 30 to 40% being by no means uncommon, and they are always associated with a development of cracks and holes in the iron. In this connection the Baltimore fire is of particular interest, because what had been previously considered acceptable fire-proof construction proved unsatisfactory, owing to the damage done to the masonry by the swelling of the cast iron members of the ironwork construction. Floor levels were destroyed, and walls which had in other respects withstood the action of the fire, were found to be useless, owing to their having been forced out of the perpendicular from this cause. The same fire also furnished an illustration of the fact that under the same treatment mild steel does not grow. In spite of the entire inflammable contents of a sixteen storey building being burnt, the steel framework remained plumb and intact. Indeed, it is well known that both mild steel and wrought iron contract slightly under the very treatment that causes the swelling of cast iron. The practical problem, therefore, was to find an alloy intermediate between cast iron and mild steel, which would neither contract nor expand after repeated heatings.

As is well-known, all commercial cast irons are complex substances. The grey irons, which are exclusively used for the above purposes, contain the elements carbon, silicon, sulphur, phosphorus and manganese, the first two in notable amounts. Further, some of these elements are present in the free state, others are combined, and one of them may be present in both conditions. Carbon may be present in the free state as graphite, and also combined as carbide either of iron or iron and manganese. Silicon occurs in solid solution in the iron as iron silicide. Sulphur may be present as a special constituent as manganese sulphide or iron sulphide, or both, while phosphorus occurs as iron phosphide, a substance of limited solubility in iron. Moreover, there are dissolved gases, of which hydrogen is the principal constituent, as to the nature of whose occurrence nothing is really known. The question, therefore, which arose at the outset, was which constituent or combination of constituents is it which is influential in causing growth, and do any of the constituents present act in a retarding direction. These questions had to be answered before any scientific attempt could be made to produce a cast iron whose volume did not change on repeated heating.

A full description of the writer's investigation of this problem is contained in his publications in the *Journal of the Iron and Steel Institute*, and of the *Staffordshire Iron and Steel Institute*, and it is only possible to give a summary of the methods and conclusions in this article. As regards methods and the conditions of the experiments, the following data should be cited. The irons were heated for four-hour periods at 850° to 900° C., and between each heating the best part of a day was allowed to elapse. The test pieces for growth measurement were in the form of cylindrical bars, and they were measured both longitudinally and diametrically to 0·0001 of an inch. It was considered desirable to expose them to moderately severe conditions without going so far as to put them in a fire or gas flame, a treatment which would rapidly have changed their chemical composition. Accordingly they were heated in a cast iron retort, placed in a large clay muffle heated by gas externally in a large Fletcher furnace. In the centre was a tube for the thermo-junction used for temperature measurements, and the lid was luted in with clay in order to diminish air access. Although the specimens were protected from the direct action of the flame, the results showed that the products of combustion of the flame do enter the retorts and cause a scale to form on the specimens, but it was only after a considerable number of heatings that the accuracy of the measurements is affected. The bars were always cooled at approximately the same rate, and they were not measured till the next day, the greatest care being taken that they were at the normal laboratory temperature.

The first experiments were designed to test the influence of carbon on growth, and were carried out with the purest commercial iron carbon alloys that could be prepared, which were, of course, *white* irons. The net result of these was to show that so long as the alloys remained white, not only did no growth take place, but there was a slight shrinkage which seldom exceeded 0·5%. One member of the series, however, that containing 4% of carbon, behaved somewhat remarkably. It contracted in volume for twenty-six heats. The contraction then stopped, and a very slight expansion set in, but it was not until the thirty-seventh heat that the bar reached its original size. After this it grew steadily, and after the ninetieth heat, it was found to have grown nearly 7%. The explanation of this is that growth was caused by the separation of temper carbon and its gradual development through the bar, thus producing a grey iron. So long, however, as the bar remained white no growth occurred. The moment *free* carbon appeared, growth was evident, and as it increased so did the growth. Free carbon was thus proved to be indispensable to the growth of cast iron. The absolute figures, however, were much smaller than those shown by grey irons under similar treatment. The next constituent tested was silicon. For this purpose six alloys containing constant carbon (about 3·8%) and silicon ascending in steps of 1% from 1 to 6% were cast, all other constituents being present in very small amounts. With this series a large number of experiments were made, and from it the chief agencies at work in the growth of irons after repeated heating have been detected. The growths obtained—and rapidly obtained—ranged from about 15·5 to 63%, the last an enormous figure. The lower silicon members kept their cylindrical form well and developed only small surface cracks. On the other hand, the higher silicon alloys cracked extensively, and the 6% alloy broke into several pieces. On plotting the growths against silicon percentages, it was found that, broadly speaking, the former was proportional to the latter. Fuller investigation has shown conclusively that silicon is by far the most important agency in the production of growth, and in fact that an estimation of the silicon percentage is about the quickest method of obtaining an approximation to the amount of growth that any given alloy may be expected to undergo. Broadly speaking, 1% of this element causes about 11% of growth. Simultaneously and progressively with growth an increase in weight occurs. This is caused by the penetration into the iron of the furnace gases and their oxidation of the silico-ferrite to a mixture of silica and iron oxide. Not until the oxidation of this constituent is complete does the growth stop, and it is the separation of these constituents which mainly cause, not only the growth and the cracking of the specimens, but also the loss of their metallic character and the deterioration of their mechanical properties. In a word, it is the enormous force exercised by oxidation which is the main cause of growth.

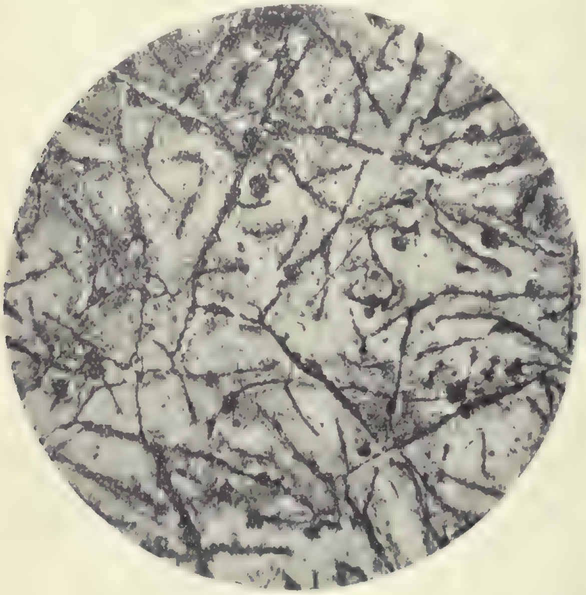
FIG. 1.

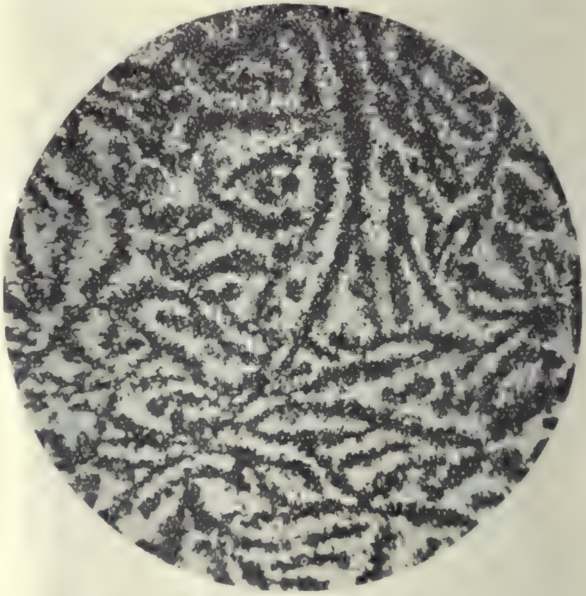
FIG. 2.

The complete revolution in the structure of the alloys produced during growth is clearly seen in the preceding two photographs. Fig. 1 represents the structure of the original casting in which the black lines indicate the graphite plates and the remainder the solid solution of iron silicide or silico-ferrite in the iron. Fig. 2 is typical of the structure after growth is complete. It will be seen that the sharp graphite lines have disappeared and been replaced by blurred markings. It is here that the separation of silica and iron oxide has taken place, the furnace gases having penetrated along the slits caused by the difference between the expansions of the iron and the graphite on heating.

Another agency at work in growth is the pressure set up in the interior of the metal by the expansion of the dissolved gases on heating—an expansion which is about four hundred times that of the iron, and which, especially in the earlier stages, causes the formation of holes. The final result, therefore, is a highly oxidised porous and cracked material, whose specific gravity is considerably less than that of the original iron.

The effects of the remaining elements can be summarised as follows :—Phosphorus not only does not cause an increase in growth, but a marked diminution, *viz.*, between 2·5 and 4% for corresponding irons. Moreover, it retards the rate of growth and renders it rather more regular. With regard to sulphur, the amount present is invariably small, rarely reaching 0·2%. Taking this into consideration, together with the tendency of sulphur to keep carbon in the combined condition in irons, it is quite certain that this element does not contribute appreciably to growth. If anything, its influence is in the opposite direction. Manganese is a most important retarding agency. Experiments have shown that in all cases it retards the rate of growth, and in the majority of cases it diminishes the absolute amount.

Finally, dissolved gases are important factors in the growth of " close " grey irons, but not of " open " ones. Their influence is most powerful when the silicon does not exceed 1%, and in such cases they may cause a growth of 10%. Between 1·75 and 3% of silicon they may be responsible for growths of 1 or 2%. Above this their influence is *nil.*

Growths of a similar character, though less in amount, are caused by superheated steam at temperatures of between 400 and 600° F. The writer's investigation of these has led him to the conclusion that here also oxidation is the cause of growth, and that the steam enters through the slits caused by the difference between the expansion of graphite and silico ferrite in the iron. The slits are widened, the graphite is slowly oxidised, the silico-ferrite is also gradually oxidised, and the specific gravity of the material is substantially lowered.

Summarising the position, it may be said that the oxidation of silico-ferrite is the prime and direct cause of growth, but that the presence of graphite or free carbon in some form is also necessary, otherwise no channel can be formed for the oxidising gases. In the " close " irons, the pressure of dissolved gases also plays a part. Of the remaining constituents, phosphorus and manganese are valuable retarding agents, while sulphur is never present in sufficient amount to have any appreciable influence.

The conditions of growth having been fully worked out, possible remedies can now be considered, and these will be dealt with in a future article.

Note.—The author expresses his thanks to the Staffordshire Iron and Steel Institute for the loan of the above illustrations.

(*To be continued.*)

MODERN WHITE PIGMENTS.

By C. A. KLEIN.

THE subject of paints has of recent years become one on which public attention has been focussed, largely in consequence of the incidence of lead poisoning which is observed amongst those engaged in the manufacture and use of paints containing a lead base, and this has been an important factor in the recent history of the development of the paint industry. It is only within the last few years that white lead has encountered any serious opposition, although substitutes of various kinds have been offered for many years. The progress of the present substitutes is the direct outcome of the application of experience gained after extensive and costly experiments. In the early days it was soon discovered that substitutes must have properties other than dazzling whiteness and chemical purity, and further that the necessary properties were not easily attained. The patent records cover an enormous range of white substances, few of which have proved of any practical value. It is only proposed to deal with white pigments in this article, as either alone or as basis for coloured paints, such pigments constitute the greatest portion of the paint now used.

For years a keenly conducted controversy has been waged with regard to the respective merits and demerits of white lead and its substitutes, and the object of the writer is to give a short account of the products which at the present time are of commercial importance.

The controversy can only be settled after careful and organised investigation, and at the outset demands some definite agreement as to a basis of comparison for the different purposes for which paint is used, *e.g.*, indoor, outdoor, exposure to sea air, etc. If such an agreement was made it would go far towards a settlement and there would be less argument as to the exact meaning of such expressions as "covering power," etc., which at the present time have meanings which vary considerably. Comparison can only be made on broad lines, and the basis must be so comprehensive as to merit the term "painting value" in which all the factors which determine the provision of a well decorated and protected surface, have received due recognition, *e.g.*, cost of materials, cost of application, life of paint, cost of repainting, etc.

The failure of many of the earlier substitutes has been responsible for a marked conservative attitude in the painter, which is not conducive to the necessary co-operation of theory and practice, but this barrier is slowly being removed and more desire to try new materials is apparent.

At the present time it cannot be maintained that any single known pigment is ideal for all purposes, and the possible preparation of such a product appears doubtful. It is not improbable that the solution of the problem lies in the proper selection of the pigment or mixture of pigments whose properties are most desirable for the proposed work.

It has been clearly shown that the weakness of one pigment can be removed by the addition of other pigments, and that in many cases a mixture is advantageous. The present white pigments now in use in any considerable quantities number only four, viz. :—white lead, basic lead sulphate, zinc oxide, and lithopone, and the following notes give outlines of the history and manufacture of these four products.

White Lead.—The early history of white lead is of great antiquity, and presents few interesting features from a scientific standpoint, except that the records show that the conversion of metallic lead into carbonate was by means of the acetate, a feature which still holds in all present processes, though it is of interest to note that recently a patent was granted for the use of amino acids, which indicates a desire to depart from the time-honoured and effective method.

The Dutch Stack method is the oldest process now adopted, and all other existing processes have been designed with a view to more quickly carrying out by various means the reactions known to take place in the stacks. In the ordinary stack process a period of about ninety days is required for conversion of the metal into carbonate, whereas in some of the newer processes the complete operation occupies less than 12 hours.

Although the actual Dutch Stack process has not been subject to much alteration for many years past, there has within recent years been very considerable advance from a chemical and mechanical standpoint, and much bacteriological work has been carried out with the object of controlling the fermentation of the tan or other waste product used for the production of carbonic acid gas. These advances have doubtless been necessitated by the progress made by the more recent quick processes which have after many reverses been firmly established in various countries.

Of the newer processes, the "Chamber Process," which claims to show the closest mechanical relationship to the stack method, consists in the exposure of thin sheets of lead to artificially-produced carbon dioxide and steam in the presence of acetic acid vapour. The process is used in England and largely in Germany, but curiously has not found application in the United States of America. The product is of excellent colour and occupies a recognised position amongst users. Modifications of the chamber process, where still larger surfaces of metal are exposed, *e.g.*, lead sponge and fibre, have been tried with varying success. In the United States of America processes are in use in which finely-divided lead is oxidised and hydrated and afterwards converted into basic carbonate by means of purified boiler flue gases.

A number of processes, termed "wet processes," are the outcome of the method introduced by Thenard in 1801. The Thenard process consisted of the precipitation of white lead from a solution of basic lead acetate, using furnace gases containing from 12 to 17% carbon dioxide. The improvements which have been made in the process deal with the method of obtaining the basic acetate solution, use of pure carbonic acid gas, conversion under pressure, etc., and are of practical importance only.

The Bischof process depends on the conversion of a specially prepared lead hydrate into carbonate, using a definite quantity of normal acetate of lead as catalyst.

Many of the above processes are supplemented by purification methods for the removal of uncorroded lead, lead acetate, and neutral lead carbonate which would adversely affect the product as a paint material.

Precipitation by alkaline carbonates, though often suggested, has not proved to be of practical value; further, as yet, the electrolytic processes have made no progress.

White lead is sold either as a dry powder or ground in oil in the form of paste containing from 6 to 8% of linseed oil. Commercial white lead approximates to the composition $2PbCO_3$, $Pb(OH)_2$, and it is frequently stated that this composition is the most desirable, though there is little to support this conclusion. The exact chemical composition of a pigment is of little or no value in determining its pigment value, and its importance is much overrated, whilst the physical condition which is the determining factor is frequently ignored.

Chemically there is little difference between the products of the present processes, but physical differences are more common, and the successful working of a white lead process lies in the control of the factors which produce the best physical condition commensurate with a reasonable latitude as regards chemical composition.

The bulk of the white lead sold is pure, but a small quantity of "reduced" white lead finds application. The "reduction" is effected by the use of barytes on a recognised scale, and white lead containing barytes must be marked "reduced." Few cases of fraudulent adulteration take place in England owing to the efforts of manufacturers in this connection.

The specific gravity of white lead is higher than that of any of its substitutes—the figure varies somewhat according to the method of preparation and chemical composition, but 6·5 may be considered an average figure.

Basic Sulphate of Lead or Sublimed Lead.—The use of basic lead sulphate as a paint material was first suggested by Bartlett in 1866, and a process was patented by him in 1870 for its preparation from Galena. The progress made was comparatively slow until within recent years, but now the product has very extensive use in the United States of America, and more recently its manufacture has been introduced into England. The process consists in the furnacing of high grade galena which has received a preliminary jigging and crushing. The furnacing is carried out in a special type of blast furnace, whereby lead sulphide is volatilised and oxidised. The resulting basic sulphate is collected dry in goose-neck condensers and bag filters.

The chemical composition of basic sulphate varies between the compounds (PbO, $PbSO_4$), and (PbO, $2PbSO_4$). The impurities consist of foreign substances either volatilised from the galena or carried over mechanically by the blast. When zinciferous galena is used a notable quantity (about 5%) of zinc is found in the product. The slight creamy colour frequently observed is attributed to iron. The product consists of particles of uniform size in an extremely fine state of division.

It is sold dry, or in an oil paste containing about 9% linseed oil. The specific gravity is approximately 6·2.

Zinc Oxide.—The use of zinc oxide as a substitute for white lead was first suggested by Guyton de Morveau about 1780, whose suggestion encouraged Courtois, who had also been engaged on the problem, to undertake its manufacture on a large scale, and in consequence Courtois established businesses in Dijon and Paris. The progress made during the next sixty years was very slow in spite of the support of men of the standing of Fourcroix, Berthollet, and Vauquelin, and it was not until about 1844 that Jean Leclaire commenced the famous campaign which after long-drawn struggles culminated in the French Act of July 20th, 1909, interdicting the use of white lead in all paint work on buildings after 1914 under certain conditions.

Since its early introduction many improvements have been effected in the method of manufacture and quality, with the result that zinc oxide has now very extensive application.

Two types of zinc oxide are marketed, known as "indirect" and "direct," and these are prepared as follows: "Indirect" oxide is prepared from spelter, and is therefore comparatively chemically pure. The process consists of the oxidation by air blast of the zinc vapour obtained by the distillation of zinc from retorts of special construction.

The oxide so produced is passed through a series of cooled pipes, thence to settling chambers. The purity and colour of the oxide is determined by the distance it is carried in the settling chamber, and the product is graded by this means. Qualities are branded in seals, *e.g.*, green seal, red seal, etc. This process is used in Europe and to some small extent in Pennsylvania. The oxide is excellent in colour and comparatively free of impurities.

The "direct" process, which produces zinc oxide direct from the ore, is of American origin, and was originally due to S. T. Jones, who, in 1850, erected a special furnace for this purpose. The commercial application of the process was established five years later by Wetherill, who had made material improvements on the original scheme.

During the last thirty years the output of this process has increased enormously. Wetherill first applied the process to the New Jersey Franklinite ores. The New Jersey ore is a complex of Franklinite, Willemite, Calcite and occasionally Zincite, having an average zinc content of 25%. Process takes place in three stages, viz.: (1) Removal of sulphur from ore by roasting; (2) magnetic separation and jigging of roasted product; and (3) reduction of zinc oxide in ore to metal with volatilisation and subsequent oxidation. The oxide is collected in chambers followed by bag filters.

The product so obtained compares favourably in chemical purity with that obtained by the "indirect" process, but it was found that this was not maintained when western ores were treated. This is due to the different chemical composition of the western ores, which are blendes, and contain sulphur in quantity together with some lead. The roasting of western oxides yields large quantities of sulphur dioxide, and in some cases this is used for the manufacture of sulphuric acid. The subsequent treatment of the roasted ore is similar to that adopted for eastern ore. Lead (as basic sulphate) is present in western oxide up to about 6%. The "direct" process has been applied to European ores, which are somewhat similar in composition to the western ore, and here again the impurities affect the final product, so that European direct oxides almost invariably contain lead, and this is recognised in some Continental specifications. The colour of direct oxides, other than New Jersey, is not equal to that of the "indirect" oxides, and great care must be taken to avoid the formation of zinc sulphate in the product, owing to its injurious effect on the paint film.

The product is graded into qualities according to colour and lead content, the different grades being distinguished as red seal, green seal, etc. At present there is no generally accepted opinion as to the superiority of one type of oxide over the other, though it is claimed by some that the small quantity of basic lead sulphate present in some "direct" oxides increases the stability of the resulting paint film.

In America so-called "leaded zincs" are prepared by furnacing mixtures of galena and blende. These contain from 20 to 30% of basic lead sulphate, together with 70 to 80% zinc oxide.

Various wet processes (precipitation and electrolytic) have been suggested for the manufacture of zinc oxide, but as yet have not assumed commercial importance.

Zinc oxide is sold either as a dry powder (specific gravity about 5·6) or as an oil paste containing 14 to 20% of linseed oil.

Lithopone.—Lithopone or lithophone are generic names given to a class of pigments of varying composition. The highest grade lithopone contains about 28% zinc sulphide, 70% barium sulphate, 2% zinc oxide, whilst the lower grades contain less zinc sulphide and more barium sulphate, the reduction usually being effected by mixing the high grade with diluents.

The manufacture of lithopone was first patented by J. B. Orr in 1876, and the product sold as Orr's White Enamel and Charlton White. In 1876, Griffith, and 1879, Griffith and Crawley, were granted patents for improved processes. Since that date very numerous patents have been obtained, generally of little practical value. The manufacture of lithopone, although originally an English process, has not made much headway in England, but on the Continent of Europe the process has assumed huge proportions, doubtless owing to anti-white lead agitations. The U.S.A. production is also considerable.

Products of varying composition (frequently mixtures of lithopone with other white pigments) are sold under fancy trade names, which give no indication as to composition. The term "white zinc" is sometimes wrongly applied to lithopone. Zinc white or white zinc should always be zinc oxide.

Lithopone is prepared by the mutual precipitation of barium sulphate, and zinc sulphide using solutions of barium sulphide and zinc sulphate. Mutual precipitation ensures homogenity of product, which is most desirable in a paint material.

The solution of zinc sulphate is prepared direct from the ore in Germany, whilst the American practice is to dissolve spelter or by-products containing zinc. Barium sulphide is prepared from barium sulphate by reduction with carbon in specially constructed furnaces.

The furnace mass is leached with water and the solution so obtained purified. The solutions of barium and zinc must be pure otherwise precipitation carries down impurities which seriously affect the colour.

The precipitate of lithopone is dried and furnaced at high temperature, and is then quenched in cold water, which increases the density and at the same time reduces the oil absorption.

In the operation of calcining, a small portion of the zinc sulphide is converted into oxide. Various additions are made to the furnace charge to minimise this oxidation. The substance added being one which will on volatilisation produce an inert atmosphere in the furnace charge and so prevent oxidation. The quenched material is ground in water and the product dried.

Lithopone is at times curiously sensitive to light—in strong sunlight a painted surface sometimes rapidly becoming grey-black in colour. The white colour is regained in the absence of light. The cause of this phenomena is not understood, and though many remedies have been suggested, none can claim to be absolutely effective, the change occurring in specially treated products with disconcerting irregularity.

Lithopone is sold as a dry powder, specific gravity about 4·2, or as an oil paste containing from 17 to 18% linseed oil.

Ready-mixed Paints.—The foregoing covers practically all the white pigments in use as bases for oil paints. Many additions are made when ready-mixed paints are prepared, but usually the principal base consists of one or more of the four substances described.

The sale of ready-mixed paints to the painter is established on an extensive scale in America, and in many cases the paints are composite, being frequently mixtures of two or more of the following, viz:—

Zinc sulphide, white lead, zinc oxide, leaded zinc, lithopone, basic sulphate of lead, gypsum, talc, silica, alumina, barium carbonate, barytes (natural and artificial), calcium carbonate, magnesite, china clay, French chalk, asbestos, etc.

Ready-mixed paints afford excellent opportunities for adulteration of both base and vehicle, and so serious has this become in the U.S.A. that certain States have enacted that all paint tins shall bear a label on which is clearly indicated the composition of the contents.

The sale of ready-mixed paints is increasing in England, though as yet the painter buys the bulk of his white pigments in the form of a stiff paste which he himself reduces to a liquid state by suitable thinners.

Production of Diastase During Flooring.—Arthur R. Ling has recently pointed out the advantages of the presence of saline matters on the steeping process in Malting (*J. Inst. Brewing*, May 18th, 1912). He points out that on the Continent the practice of adding lime water has been prevalent for many years. Advantage is claimed both in the cistern and the steep. Interesting results are recorded in the paper, which indicate the large increase in diastase during the "withering" process. The author insists on the advantage of "slow, cool generation and efficient withering."

It is shown that there is a general increase in diastatic power during flooring throughout the corn. This takes place in the proximal, median, and distal portions of the corn, but the increase is greatest in the endosperm adjunct to the adsorptive epithelium as previously noted by Brown and Morris. The increase in diastase commences with the first appearance of the rootlet. It increases steadily during the period of active growth of acrospire and rootlet, within malting limits; but is greatly stimulated when the rootlets wither through loss of moisture. The increase here is suggested as one of auto-digestion.

Peat in Canada.—Canada is rich in peat, which will some day, no doubt, play an important part in the development of the country. It has been estimated that the known peat bogs of Canada, which are probably but a small part of the total, cover an area of 36,000 square miles.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE ACTION OF ACIDS ON CONCRETE.

By Walter C. Hancock, B.A. (Cantab), F.I.C.

(*Continued from page 225.*)

In a previous article reference was made to the disintegration of a concrete drain, caused by the action of sulphuric acid on the cement, and the source of the acid was traced to the sulphur in pyrites present in the soil in which the pipes were laid. Other instances of similar disintegration have been recorded in which the sulphuric acid seems to have been produced in a slightly different manner. At Charlottenburg some drains were laid partly above and partly below the level of the sub-soil water, and the inside of the drain was badly attacked above the level of the liquid contained in it, although below that level the material was sound. In the damaged portions of the drain the stone blocks began to flake off and the mortar of the joints became softened, and a chemical examination of the defective parts showed the presence of calcium sulphate in them. The explanation suggested to account for the formation of the sulphuric acid that had combined with the lime of the cement was that the sulphuretted hydrogen in the sewer gases had been decomposed and sulphur deposited in the form of powder, which in the presence of moisture and of the oxygen of the air that found its way into the sewer was converted into sulphurous and then by further oxidation, into sulphuric acid. The same explanation has been advanced to account for similar failures in other places. In one instance the source of the sulphur was attributable not to sewer gas, but to sulphuretted hydrogen produced by the decomposition of a layer of grass which had been covered over with soil and not removed before the concrete was applied. It has also been suggested that in some cases the gases may combine with the lime of the cement to form calcium sulphite, as an intermediate product, which is afterwards converted by the oxygen of the air into calcium sulphate. In the case of peaty soil water it is also possible that the lime of any calcium sulphate already formed may combine with organic acids, and the sulphuric acid thus liberated become available to combine with a fresh quantity of lime in the concrete, and so give rise to a continuously progressive decomposition.

Amongst other acids, acetic would combine with the lime, and the calcium acetate formed may be washed out of the concrete, or if not, may crystallise in it, and so exert an expansive force. Mineral oils and mineral acids produce a continuous destruction of concrete, and any fatty acids formed yield lime soaps which also have a weakening effect.

An attempt has been made to sketch briefly the destructive action of acids on concrete, and the problem naturally presents itself to the mind, how concrete can be protected from the action. In the first place, when bricks are laid with a cement mortar, it has been found in one instance that bricks with the least porosity and with the lowest content of lime are least attacked. Obviously also, from what has been said as to the origin of sulphuric acid, by oxidation of either elemental sulphur or of the lower oxide, the exclusion of air is a desideratum in such cases, and it is also advisable that sewer gases should be removed from the sphere of action as soon as possible. But in addition to these protective measures, other means of excluding the action of acids on concrete have been tried. In some cases a coat of tar has done good service, but as a rule, if the acids are derived from the soil or from sub-soil waters, more elaborate means have had to be requisitioned. The impregnation of the concrete with some fatty or oily substance has often been strongly recommended, but the general experience seems to be that these tend to reduce the strength of the concrete, and the use of some thoroughly impervious coating has proved far better. In the case of the Berlin Underground Railway several layers of thick tar supplemented with a coating of asphalt have stood the action of acids well. Foundations laid in a peaty soil may also be protected with sheet-piling, which with the base is covered with a layer of clinker, and this with three layers of a covering paste. In some cases a layer of clay has been introduced between the concrete and the sheet-piling, but in spite of the higher cost, the layer of asphalt on the outside of the concrete may be preferable. Where concrete is laid in peaty soil, the soil excavated should be replaced by sand. In addition to such protective methods, of course it is advisable always to employ a clinker poor in lime, and also to proportion the aggregate so that the voids are reduced as far as possible, as the less pervious the concrete, the less the danger of penetration by the destructive liquids.

RECENT ADVANCES IN THE ANALYSIS OF METALLURGICAL MATERIALS.

By J. A. Pickard, B.Sc., A.R.C.S.

In attempting to review recent progress in the analysis of metallurgical materials the number and the variety of the improvements suggested—each of importance chiefly to a small section of workers—make it very difficult to present the whole in a comprehensive article. In the following account an attempt has been made to group together as far as possible the advances dealing with new work on each problem, but within the limits of space at command it is inevitable that brief details only can be given, and that much must escape mention.

Probably no estimation is more frequently made, or more difficult to carry out with exactitude, than the estimation of sulphur or sulphuric acid as barium sulphate. In view of this a paper by Johnston and Adams[1] in continuation of previous work by Allen and Johnston[2] dealing with the idiosyncrasies of this precipitate is of particular interest. An ordinary estimation using about 1 gm., of a sulphate may give a correct result, following the usual procedure of precipitating with boiling barium chloride in boiling solution, but if so, this is due to compensating errors, as the precipitate carries down with it both barium chloride and free sulphuric acid which cannot be eliminated by washing. The authors recommend a much more lengthy procedure, precipitating by the addition of barium chloride drop by drop at intervals, filtering after 18 hours and finishing as usual. Corrections are then applied depending on the nature of the solution. In order to avoid precipitating barium sulphate—in the estimation of sulphur in steel—in concentrated solutions of iron salts, K. K. Jarvinen[3] first precipitates as benzidine sulphate, and finally converts this into barium sulphate.

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[1] *Journ. Am. Chem. Soc.*, 1911, 33, 829.

[2] *Journ. Am. Chem. Soc.*, 1910, 32, 588.

A very interesting paper by C. H. Ridsdale and N. D. Ridsdale[4] deals with the mechanicalising of analysis as a means of procuring greater speed and accuracy. The advantages of proceeding in an invariable and uniform manner are many, especially for works analysis. Concordant results are quickly obtained and time and labour are greatly economised; while the personal equation is almost eliminated and analytical work can be put into the hands of practically untrained men. It is interesting to notice the variations obtained by a number of skilled chemists in such a simple matter as the estimation of iron in an iron ore, using the same method,[5] while even the International Commission on methods of steel analysis some years ago[6] was unable to obtain completely concordant figures. It is very important to bear in mind, however, that the actual percentage of the constituent in the material is the result required for specification purposes, and that an arbitrary figure obtained by pursuing a particular series of operations is only of value as a check on uniformity of material. The methods at present worked out by the authors give results in excellent agreement with the true figures, but as no method is universally applicable, concordant duplicate results by different methods are desirable in any question of materials being up to specification.

Some organic reagents have recently been applied to inorganic analysis with marked success. Dimethylglyoxime, though not a new reagent, in view of its giving a brilliant scarlet precipitate with nickel salts and practically nothing with cobalt[8] is coming into favour, and the estimation of nickel in German silver is no longer a matter of much difficulty[7], [9]. Potassium methyl xanthate is also a sensitive reagent for nickel and cobalt[10] giving a precipitate with both metals, the nickel precipitate being soluble, and the cobalt insoluble, in dilute ammonia. With chromates, 1 : 8-hydroxynaphthalene-3 : 6-disulphonate yields a red or violet colour which permits of 0·0008 gm., of chromium being detected in the presence of iron. The reaction can be made the basis of a colorimetric estimation. Cupferron (nitrosophenylhydroxylamine ammonium) permits the precipitation of ferric iron in a condition readily ignited to oxide from solutions containing Al, Cr, Ni, Co, Zn, Ca, Sr, Ba, and Mn.[11] Copper is precipitated along with the iron but may be removed by washing with ammonia. A method of preparation of cupferron is given by Baudisch.[12] Pyridine has been utilised by Sanchez[17] in the separation of iron and manganese. The iron precipitate is stated to be uncontaminated with manganese unless the latter is very high, while 0·0005 gm., of manganese can easily be separated from 1 gm., of iron. A very interesting new reaction for ferrous salts has been discovered by Chautschkoff.[23] A solution of naphthenic acid in light petroleum when shaken with a solution of a ferrous salt is stated to extract all the ferrous oxide, forming a chocolate-brown layer. The reaction is easily applied to the separation of iron and aluminium.

The estimation of carbon is the subject of several papers. Of these may be mentioned the method used by Stadeler,[13] due to Wuest, which consists in burning 0·3-·05 gm., of the material in oxygen at 900° C. after mixing with 1·5-2·5 gm., of an alloy of three parts antimony to one of tin. It is stated to be particularly useful in the analysis of alloys not attacked by chromic acid mixture. The method of Mahler and Goutal[14] consists in burning the steel in a calorimetric bomb in compressed oxygen, absorbing the carbon dioxide in baryta and titrating with acid. H. de Nolly[15] burns the steel in an asbestos capsule in a litre flask supplied with oxygen under a small pressure, by passing an electric current between electrodes. The carbon dioxide is absorbed in baryta, which is placed in the flask before starting the combustion and titrated with acid. This method is stated to be very rapid, but the completeness of the combustion and non-influence of the electrodes used needs demonstration. The incorrect results sometimes obtained when carbon is estimated after treatment of the steel by copper potassium chloride seem to be definitely due to the presence of carbon containing impurities in the reagent[16] which agrees with the writer's experience. A micrographical method, of only approximate accuracy is given by F. Robin.[18]

A convenient method for determining carbon monoxide where this estimation is frequently needed is due to L. H. Levy.[19] The method depends on aspirating the gas through suitable purifiers and ultimately oxidising the carbon monoxide to carbon dioxide by warm iodine pentoxide and absorbing it in a known volume of standard baryta. The latter is coloured pink by phenolphthalein, and when the colour disappears a reading of the amount of gas which has passed through is made, and hence a simple calculation yields the percentage by volume. A drawback to this method is the necessity of carrying it out very slowly, as the complete oxidation of carbon monoxide to dioxide—by iodine pentoxide without danger of oxidising other constituents in the mixture—takes a considerable time.

The rapid estimation of zinc is still in an unsatisfactory state. Kemmerer[20] recommends an electrolytic estimation in strong caustic soda solution with rotating anode. K. Voigt[21] and[22] relies on solution in aqua regia and separation of zinc by means of ammonia, afterwards titrating with ferrocyanide containing sodium sulphite. Copper is first removed from the ammoniacal solution by aluminium, and manganese by a small amount of bromine. Neither of these methods is any quicker than the ordinary sodium sulphide titration method, using suspended ferric hydroxide as indicator, and it is doubtful if the accuracy is greatly increased. It may be mentioned here that for the latter titration an external indicator of cadmium nitrate paper has been found very satisfactory.[24]

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[3] *Chem. Soc., Abstracts*, 1912, ii., 486.

[4] *Journ. Iron and Steel Institute*, 1911, *83*, 332.

[5] *Zeit. fur Angewandte Chem.*, *24*, 1118.

[6] *Journ. Iron and Steel Institute*, 1904, p. ii., 221.

[7] Fred. Ibbotson, *Chem. News*, 1911, *104*, 224.

[8] Del Campo and Ferrer, *Chem. Soc., Abstracts*, 1911, ii., 825; 1912, ii., 95.

[9] *Journ. Ind. and Eng. Chem.*, 1911, *3*, 255.

[10] *Chem. Zeit.*, 1911, *35*, 277.

[11] *Journ. Anal. Chem.*, 1911, *50*, 35.

[12] *Chem. Soc. Abstracts*, 1911, ii., 939.

[13] *Metallurgie*, *8*, 268.

[14] *Comptes Rendus*, 1911, *153*, 549.

[15] *Revue de Met.*, 1911, *8*, 391.

[16] *Journ. Ind. and Eng. Chem.*, 1911, *3*, 577.

[17] *Bull. Soc. Chem.*, 1911, iv., *9*, 880.

[18] *Revue de Mecanique*, *27*, 405.

[19] *Journ. Soc. Chem. Ind.*, 1911, *30*, 1437.

[20] *Journ. Ind. and Eng. Chem.*, *2*, 375.

[21] *Zeit. fur Angewandte Chem.*, 1911, *24*, 2195.

[22] *Zeit. fur Angewandte Chem.*, 1912, *25*, 205.

[23] *Chem. Zeit.*, 1911, *35*, 463.

A very large amount of useful work on the analysis of iron alloys such as Ferro Uranium, Ferro Zirconium, Ferro Titanium, Ferro boron, Ferro tungsten, and others has been carried out by Slawik, W. Trautmann, Wunder and Jeanneret, Raulin, Hinrichsen, and others, but it is impossible to give details here.

The separation of calcium from large quantities, and from small quantities, of magnesium has also received a good deal of attention, but no consensus of opinion as to the most reliable methods has yet been reached, while many other useful methods of procedure must be left unmentioned.

ALKALINE WATERS OF THE LONDON BASIN.

By S. RIDEAL, D.Sc., F.I.C.

IN a paper on the "Origin of Carbonate of Soda in Natural Waters and Mineral Deposits" in THE CHEMICAL WORLD of last January, I gave some old and new explanations of how this feature had been caused. A valuable contribution to the subject was read by Dr. Thresh to the Essex Field Club on March 30th, 1912, in which he brought forward the results of his mineral analyses of a large number of alkaline waters in his district, of several in Kent, Surrey and Middlesex, and of some in other counties, and even from Damaraland (South Africa), and Denmark, for comparison. The long-known salient point is that where the chalk is uncovered, as in western Essex, the water from deep wells contains very little sodium chloride, no sodium carbonate, but has a high hardness; that is, there is a predominance of lime and magnesia compounds. From chalk under the clay, as in eastern Essex and the rest of the London Basin, the water is soft, but alkaline and saline, owing to sodium salts—carbonate, chloride and sulphate, and also silicate. The significance of the last constituent has not been sufficiently noticed, since in many cases it is not separately determined, but is put down, as in Dr. Thresh's analyses, as "Silica, etc." It can arise by the solvent action of the alkaline carbonate, however produced, on the silicious materials of the rocks and soils. From my own determinations of silica in a very large number of waters from various parts of the world, collated with other published analyses, I find that in ordinary drinking waters the amount of silica *in solution* has a singular regularity, and ranges very near to 1 gr. per gallon, or 1·4 parts per 100,000. The recorded separate estimations of silica in solution are not frequent: they are not requisite for usual water analysis, require large quantities, and great care in excluding suspended matter containing clay or very fine sand. These have obviously crept into Dr. Thresh's Table VII., where the Thames at Grays is reported to contain 70·4 and 15·8 parts of "silica, etc." The remaining figures in his paper for "silica, etc.," range from 0·2 to 4·3 parts per 100,000, the majority lie between 1 and 2, and the average of his 44 analyses is 1·25. This dissolved silica may be present as the colloid free acid or as a soluble salt, but must have played a considerable part in the decomposition of the rocks and in the composition of waters, as has been pointed out by several geologists, who have drawn attention to the well-known property of silicate solutions of being acted on by carbonic acid, giving alkaline carbonates and colloid silica in solution, which latter could again act slowly as an acid on silicate minerals and cause disintegration. Thereby silica, as a carrier, could occasion any number of alkaline waters. The action of hydrated silicates, or zeolites, has drawn much attention recently.

The quantity of alkaline salts in a water is of considerable hygienic importance. It is not always advisable for the community to be continually drinking a purgative or saline liquid. Dr. Thresh's analyses on a line from the bare chalk under the London Basin to the southern outcrop emphasise the amount of Ca and Mg salts at and near the outcrop, their diminution as the chalk gets deeper, and the accompanying increase in carbonate and sulphate of sodium, and common salt. But he finds that some of the waters containing least salt are derived from wells near tidal estuaries, "whilst many of the waters containing much salt are miles inland." I may here interpolate that sources of sodium chloride in waters may be (1) infiltration of sea-water; (2) geological marine strata now far inland; (3) animal contributions. The last is an ordinary index of pollution, but has to be taken in conjunction with the other factors. In the case of a well sunk in the chalk at Clacton-on-Sea, the water which rose naturally in the bore was comparatively soft and contained sodium carbonate and little salt, but as pumping proceeded it became so brackish that the well was abandoned. The same thing has happened in numerous places. In others, where a water-tight lining passes through an impervious stratum such as a layer of clay, an infiltration that affects the upper portions is excluded, and a very pure water is often obtained.

In my previous article I mentioned that while the matters in solution increase by evaporation or percolation, the carbonates of lime and magnesia tend to deposit as crusts, accompanied later by the sparingly soluble sulphate of lime, so that the carbonate of soda, which may have been originally only a trace, augments in proportional amount, and makes an alkaline water. Fisher found that chalk contained a distinct amount of sodium carbonate (*Analyst*, August, 1901 and June, 1902), and also found 0·25% in a sample of the lower Greensand.

It is, therefore, unnecessary to suppose with Dr. Thresh that wholesale infiltration of sea water is occurring almost all over the district. In support of his theory he has made mixtures in different proportions of hard chalk water and sea water, and analysed them before and after filtering them through Thanet sand "of varying thickness and of varying activity." The figures in Tables IV. and V. of his paper show a removal of calcium and magnesium salts, but we notice that in every case he records an actual increase of sodium chloride and also of the total solids, showing that a considerable amount of matter is being dissolved out of the filtering medium, unless evaporation is taking place. Sodium carbonate and sulphate appear in rather heavy quantities after the treatment, and the liquids yielded bear a general resemblance to waters from under the London clay. Where, as in the Chelmsford area, a little less salt (35 parts per 100,000) is present, the simple but not convincing explanation is tendered that dilution with a less saline water is occurring. He considers that by varying the source of the chalk water and the proportion of sea water, every water from the chalk and Thanet sands in the County of Essex and under London could be imitated. This is hardly more conclusive of the *mode of formation* than to say that almost

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[24] *Ann. Chim. Anal.*, 1911, 16, 10.

any natural mineral water can be *imitated* by blending and otherwise treating the right quantities of certain materials.

Moreover, his hypothesis fails to account for the origin of other alkaline waters which contain much more carbonate of soda than sodium chloride or sulphate, notably three examples in his Tables X. and XI. I append my own analysis of one of them, and also my analyses of the strongly alkaline water which has been lately discovered at Lake Doroninski, near Chita in Siberia.

	Parts per 100,000.		
	Na_2CO_3	NaCl.	Na_2SO_4.
Kelso, N.B., from Porphyrite (Thresh)	25·2	3·4	2·0
Skegness, from Greensand (Thresh) ..	27·6	4·0	4·0
Ditto (Rideal, 1905)	22·0	3·4	—
Lake Doroninski (Rideal, Nov., 1911)			
No. 6, 7½ ft. depth	3580	13·40	low
No. 6, ditto	4250	13·00	low
No. 8, at surface	1290	22·20	2·8
No. 9, 10 ft. depth	4910	14·20	3·8
No. 10, 11½ ft. depth	4960	13·90	low

From these lake samples lime and magnesia were practically absent. In my January paper I also mentioned Lake Magadi, in British East Africa, where the deposit is carbonate of soda with only 0·36 to 0·48% of NaCl. In that paper I gave a probable explanation of the formation of these waters and deposits, and it is evident that alkalinity can be produced in such natural liquids quite independent of present infiltration from the sea. At the same time I noticed Dr. Gans' "Permutit" method of purifying and softening water by means of natural or artificially-prepared zeolites, and then revivifying the latter by a brine solution, which suggests another way in which alkaline waters can be produced in nature. The chief natural zeolites containing soda are, according to Dana's "Mineralogy":—

			Na_2O up to per cent.
Natrolite.	Hydrated	Na, Al, silicate ..	16·5
Analcime.	,,	Ditto	14·0
Gmelinite	,,	Ca, Na, K, Al silicate	9·3
Thomsonite	,,	Ca, Na, Al silicate	8·0
Mesolite	,,	Ditto	5·5

Chabazite and Faujasite contain 4 to 5% of Na_2O. Outside the zeolite family, pectolite contains up to 9·7% of soda, and albite and oligoclase (soda felspars) nearly 12%. Many forms of these minerals altered by weathering are found.

As an analogy of the "Permutit" process Dr. Thresh finds that the Thanet Sand contains a natural zeolite which can be regenerated by brine. In explanation of the difference that is found in wells not much more than a mile apart, he suggests that the (rain) water dissolves the uncovered upper chalk, opening the fissures, and becomes hard, but that towards the centre of the basin, where the chalk is compressed by upper layers of sand and clay, the water cannot travel deeper, and "comes up through the fissured chalk into the sands above and then becomes exposed to their softening action." He remarks that mere proximity to the sea does not enable anyone to say whether a water will be salt or not, as a well near the coast may or may not contain an excessive amount of salt. It is to be supposed that the infiltration of sea water which is necessary for his theory of the regeneration of the softening powers of the Thanet Sand, is due to very long fissures or to exceptionally porous strata, since it happens so irregularly. There is one great difference between the natural phenomena and those observed in the "Permutit" method and in Dr. Thresh's experiments, namely, that the former appear constant and their causes continuous, whereas the latter are intermittent and have more or less regular periods of exhaustion, when the activity of the bed has to be renovated by passing brine. There are no signs nor causes of such alternation in the London Basin, and the only fluctuating feature is the rainfall, which makes little change in the composition of the *deep* waters and could hardly account for the facts observed. Dr. Thresh's artificial beds were capable of softening hard water, and then of hardening soft water, by giving up to the latter the lime and magnesia they had absorbed. No parallel to this has been remarked in the Metropolitan area.

The relation of bromine to chlorine, which Dr. Thresh finds high in a number of deep Essex waters, and adduces as an evidence of infiltration from the sea, is a doubtful argument in face of the large proportion of bromide that is found in some far inland springs in Germany and elsewhere. It may just as well come from prehistoric sea water, since the chalk is a marine formation.

On the whole, Dr. Thresh's theory, though ingenious, presents many difficulties, and that such far-reaching and wide-spread infiltration from the sea is now going on seems highly improbable, but the paper is a useful one and he promises further work.

Obituary.

"Mr. Humphrey Owen Jones, whose untimely death is recorded while ascending the Aiguille de Pétéret, was Jacksonian Demonstrator in the University of Cambridge and Fellow and Lecturer of Clare College. He was born near Aberystwyth in 1878. Among his contributions to scientific literature were papers on sulphur compounds, on the stero-chemistry of nitrogen, and, in association with Sir James Dewar, on iron and metal carbonyls. Recently his achievements in the field of chemical research were recognised by his election to a Fellowship of the Royal Society. At the end of last month he was appointed a nember of Lord Fisher's Commission to investigate and report on the supply of oil fuel for the Navy.

"Mr. and Mrs. Jones were married at Bangor Cathedral on the 1st of last month and went to Switzerland for their honeymoon. Mrs. Jones was Miss Muriel Edwards, a daughter of the Vicar of Bangor, and a student at Newnham College, Cambridge.

"Mr. H. O. Jones was famous amongst mountaineers in Switzerland and amongst his native hills in Wales, as famous as his namesake, Owen Glyn Jones, who met the same untimely fate. During the last few years he had established a reputation as one of the most brilliant of the younger generation of climbers. Last season it was confirmed by a series of daring first ascents. With Mr. Winthrop Young and the guide Knübel he ascended and descended for the first time the two unclimbed ridges of the Grandes Josasses, and made the first ascent of the Grépon straight from the underlying glacier, thus accomplishing the unfulfilled ambitions of two generations of climbers. It was said, indeed, at the time that after these achievements there was nothing left in the Alps to climb. His reputation for caution and knowledge of the mountains, was, however, as great as his reputation for daring."—*Morning Post.*

UNIVERSITIES AND COLLEGES.

THE CHEMICAL DEPARTMENT OF THE UNIVERSITY OF LIVERPOOL.

By Alexander Rule, M.Sc., Ph.D.

The history of the Chemical Department of the University of Liverpool illustrates particularly well the progress which has been made since the old University College of Liverpool received its Charter of Incorporation in 1881. The Chair of Chemistry founded by Mrs. Grant, of Rock Ferry, was one of the seven professorships established in connection with the College; and Dr. James Campbell Brown, Lecturer in Chemistry at the Royal Infirmary Medical School, who had taken a leading part in promoting the movement which led to the foundation of the College, was appointed first Grant Professor of Chemistry, a position held by him up to the time of his death in 1910.

Junior Laboratory.

In 1884 the College was incorporated in the Victoria University, and the old Medical School became amalgamated with the College. At this period the teaching of chemistry was carried out in the laboratories of the Medical School under very primitive conditions, but in 1884 the erection of new and extensive chemical laboratories, forming an integral part of the Victoria University scheme, was begun and on March 20th, 1886, the new laboratories were opened, an inaugural address being delivered by Sir Lyon Playfair. Ten years later a valuable addition was made to the department through the generosity of Mr. F. H. Gossage and Mr. T. S. Timmis, who combined to erect a large laboratory for senior students as a memorial to Mr. William Gossage. Sir John Brunner, Mr. E. K. Muspratt, Messrs. Lever Brothers, and others supplied funds to complete the design which included a metallurgy department, storerooms, etc.

In 1903, University College received its Charter as an independent University, and in the following year Sir John Brunner founded a Chair of Physical

Chemistry, while Mr. E. K. Muspratt came forward with the offer to erect laboratories to be devoted entirely to the study of physical and electro-chemistry. The fact that these generous gifts were made by two of the leading chemical manufacturers of the country, illustrates the growing importance attached to the study of physico-chemical methods and applications, by those engaged in the chemical industries. Dr. F. G. Donnan was appointed Brunner Professor of Physical Chemistry, and under his supervision the Muspratt Laboratories of Physical and Electro-chemistry were erected at a cost of about £17,200. The new building was opened in 1906 by Professor Ostwald.

In 1910, Mr. E. C. C. Baly, F.R.S., was appointed Grant Professor of Inorganic Chemistry in succession to the late Professor Campbell Brown.

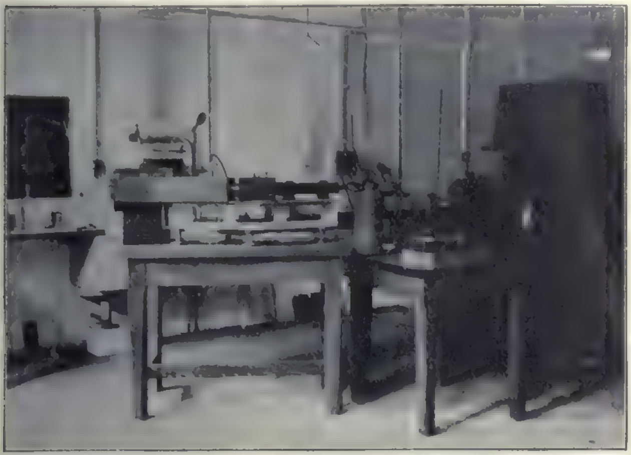
In describing the buildings and equipment of the chemical department it will be well to consider the Main Laboratories and the Muspratt Laboratory separately.

The main buildings form a handsome block, covering an area of about 1,700 square yards. On the ground floor is situated the Junior Laboratory, which is semi-circular in shape, the benches rising in tiers facing the demonstrator's table. Lockers are provided for 104 students and it is possible for 52 to work in the laboratory at one time. Behind each bench is a reagent cupboard: set in the front of the bench immediately above, and between the cupboards there are small fume chambers connected with the main ventilating system. The laboratory is well adapted for the teaching of elementary chemistry to large classes, as it is possible to give demonstrations from the table below in full view of all students, while the latter remain at their benches. Opening out of the laboratory is a wing containing a storeroom, balance-room and demonstrators' private room and laboratory. Adjoining the laboratory is a special room for the supply of sulphuretted hydrogen. On the same floor is the Metallurgical Department, which consists of two laboratories fitted with coke-fired gas, and electrical furnaces, recording and other pyrometers, and a full equipment for the micro-photography of metals. A special apparatus has recently been fitted up for testing the mechanical properties of metals and alloys at high temperatures. Experiments are now being carried out on a large scale by Dr. G. D. Bengough, Lecturer in Metallurgy, to ascertain the causes of corrosion in condenser tubes, under conditions approximating as closely as possible to those obtaining in the mercantile marine.

The laboratories and rooms on the first floor are devoted entirely to senior work. The William Gossage Laboratory affords accommodation for about 50 students and is used at present for both inorganic and organic courses. The laboratory is large and well-lighted, and is provided with steam drying ovens, a constant supply of distilled water,

WILLIAM GOSSAGE LABORATORY.

steam jets, large sandbath, etc. It is lined throughout with white enamelled brick and the roof is arched and lofty. On the same floor is the organic research laboratory, with working space for six students, also the private laboratory of the Lecturer in Organic Chemistry, balance-room for senior students, combustion-room with special safety equipment for sealed tube experiments, a dark-room, and a room for gas analysis. From the first floor access is gained to the departmental library which is housed in a room on the ground floor of the Muspratt Laboratory, and forms a connecting link between the two buildings. The library is well stocked with journals, periodicals and handbooks for purposes of reference, and also with text-books on the more advanced and specialised branches of the subject.



SPECTROSCOPIC EQUIPMENT, INORGANIC RESEARCH LABORATORY.

The second floor is occupied by the lecture theatre, which provides seating accommodation for 200 students, and is situated directly above the Junior Laboratory. Behind the lecture table is a preparation-room, and there is also a special storeroom for apparatus used in lecture experiments. On the same floor there is a small classroom, and the private room and laboratories of the Professor of Inorganic Chemistry. The inorganic research laboratory contains a full equipment for spectroscopic research, including a large spectrograph, spectrophotometer, Ruhmkorff coil and condensers. The third floor of the building is occupied by storerooms and a shop for the supply of chemicals, etc. The corridors in the main building are lined with museum cases, containing specimens of elements, minerals, organic and inorganic compounds, etc., all carefully classified, and large use is made of these exhibits for lecture purposes and for general comparison in the course of research work.

The whole building is efficiently ventilated, purified air being forced into the laboratories at various points by means of a fan, and withdrawn through the fume chambers which are directly connected with a tall shaft at the base of which a furnace, is kept constantly burning.

The Muspratt Laboratory adjoins the main buildings but possesses an entirely independent organisation. The basement contains the electrical power equipment and laboratories for electro-chemical research. The ground floor is occupied by the lecture theatre, library, workshops, preparation-rooms and photographic-room.

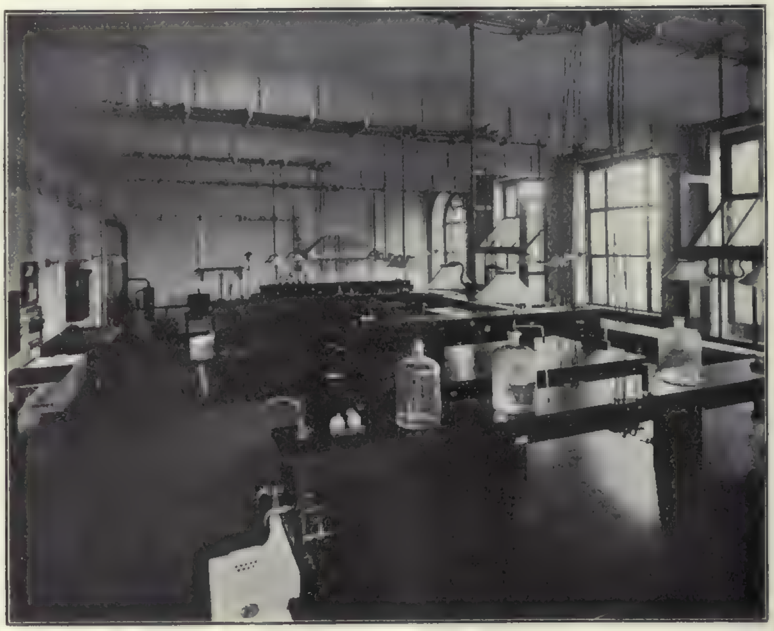
The general laboratory, containing places for 25 students, is situated on the first floor, together with a balance-room, optical-room, apparatus-room, and lecturer's private laboratory. On the second

EXTERIOR OF MAIN BUILDINGS.

floor there are four rooms devoted to research work, with ample space for 10 students; also the Professor's private room and a balance-room. The third floor is occupied chiefly by storerooms, a special apartment for distillation, and a small open air laboratory containing a stone bench fitted with gas and water.

In constructing the laboratory special attention has been paid to the electrical equipment, which is so arranged as to combine the highest efficiency with convenience in manipulation. The dynamo-room contains four generators directly coupled with three motors driven from the town supply. The generators include: (1) An 80 kilo-watt alternator, giving current up to 1,000 amperes at 10—160 volts; (2) a direct current dynamo giving 350 amperes at 80 volts, which can be used when necessary for charging the whole storage battery in series; (3) two direct current dynamos giving current up to 500 amperes at 0—50 volts. The storage battery consists of 36 Tudor accumulators of 700 ampere-hours capacity. The cells are connected to a general distributing board in the basement, from which connection is made to other boards, one being situated on each floor and acting as distributor for the benches on that floor. In the photograph of the general laboratory the system of "wiring" is clearly illustrated. All the cables and leads are kept separate from one another, and pass along the walls and roof, supported on porcelain insulators. No rubber is present in the insulating material surrounding the wires. Four leads, corresponding to two distinct circuits, pass down to each bench so that it is possible for each single student to use two different voltages, or alternating and direct current simultaneously. By connecting the two circuits in parallel, current up to 100 amperes may be obtained. At each bench there is also a switch and plug contact from which current up to 5 amperes at 230 volts may be taken from the town supply.

The equipment of the general laboratory is typical of that of the whole building. The benches are constructed of teak and to each student is allotted a working space 6 ft. in length by 3 ft. wide. A thermostat at 25° C., either gas or electrically heated, is fitted at the end of each bench. The fume chambers are exceptionally large, and are set in the window spaces. The floor of each chamber is constructed of white glazed fire-proof slabs, and the necessary draught is obtained by means of large Bunsen burners of special design. Fire-proof benches constructed of unglazed tiles set in clay are provided in each room.



General Laboratory. Muspratt Laboratory of Physical and Electro-Chemistry.

The courses of instruction in chemistry have undergone considerable reorganisation during recent years. A general course of lectures is provided for first-year students, including those working for the Honours and Ordinary Science degrees, and medical, dental and veterinary students. Except in the case of honours students, the teaching of practical chemistry is conducted entirely in classes, no independent laboratory work being undertaken until the second year. In organising the first year's practical course the chief aims have been to give to students a general idea of methods of manipulation, and to emphasise the importance of studying quantitative relationships, as opposed to the old system of confining practically the whole of the first year's work to qualitative analysis.

In the second and third years students in the honours school receive instruction in inorganic, organic and physical chemistry, devoting two terms of laboratory work to each of these three branches of the subject. It is now customary for graduates who have passed through the honours school to remain for a fourth year and carry on research work. During the session 1911-12, 22 post-graduates, including several from Continental and Colonial Universities have been engaged in research work in the various laboratories of the department.

The number of students working in the department has increased greatly during the past few years, and there is pressing need for an extension of the laboratories. The whole chemical department stands as a monument to the labours of the late Professor Campbell Brown, but it has been felt that the memory of his connection with the department and with the University should be perpetuated by permanently associating some portion of the laboratories with his name. With this object in view, a committee has been formed for the purpose of raising funds to build a new inorganic laboratory.

THE ALLOTROPY OF SULPHUR.

III. Dynamic Allotropy in Gaseous and Liquid Sulphur.

By T. Martin Lowry, D.Sc. (Lond.), F.C.S.

Dynamic Allotropy.—Allotropy, like polymorphism, has usually been regarded as being of one of two alternative types. In some cases the allotropy is *enantiotropic*, the different varieties of the element being convertible into one another by changes of temperature, as in the case of rhombic and prismatic sulphur (transition temperature 96°). In other cases the allotropy is *monotropic*, certain varieties being metastable at all temperatures, and tending constantly to pass into some more stable form; such varieties are found in nacreous and tabular sulphur, which tend to pass into rhombic sulphur at all temperatures below 96° C., and into prismatic or liquid sulphur at temperatures above 96°.

In recent years a third type of allotropy has been recognised, to which the name *dynamic allotropy* has been given. In cases of this kind the different allotropes can exist in equilibrium with one another in definite proportions over a range of temperatures, and not at the transition-temperature only. The phenomena are, in fact, similar to those of dynamic isomerism in every respect, except that they are observed in elements instead of in compounds.

Two distinct types of dynamic allotropy may be recognised in the case of sulphur, the vapour illustrating the phenomena of reversible polymeric change or *dissociation*, whilst in liquid sulphur the phenomena of reversible isomeric change or *dynamic isomerism* have been detected and studied by Professor Alexander Smith and his collegues.[1]

Sulphur Vapour.—Sulphur melts at 119° and boils at 444.5°. The vapour was shown by Deville and Troost, in 1857, to have at 860° to 1,040° C. a vapour density corresponding with the formula S_2; but Dumas showed in 1860, that at 524° the vapour density is much higher, corresponding with the formula S_6; it was therefore supposed that the dissociation taking place in the heated vapour might be represented by the balanced equation $S_6 \rightleftarrows 3S_2$. Biltz, however, showed in 1901 (*Ber.*, 1901, *34*, 2490) that still higher vapour densities, (approximating at 486° to that required for the formula S_7) may be obtained at temperatures nearer to the boiling-point, whilst under reduced pressures, and at a temperature just below the boiling-point, the vapour density is intermediate between those calculated for the formula S_7 and S_8; Bleier and Kohn (*Ber.*, 1900, *33*, 50–51) were able to carry the measurements of vapour density down to 200° C. and obtained figures corresponding with an average of 7·8 atoms in the molecule. As both "soluble" and "insoluble" sulphur have been shown to have the formula S_8, there can be little doubt that the vapour in the neighbourhood of the boiling-point contains gaseous molecules of the formula S_8, which break down progressively into molecules of the formula S_2 as the temperature is raised, $S_8 \rightleftarrows 4S_2$. The existence of intermediate molecules of S_6 and S_4 is, however, by no means excluded (see especially Preuner, *Zeit. physikal Chem.*, 1903, *44*, 733)

Molecular Weight of "Soluble Sulphur."—The only modification of sulphur which is permanently stable at atmospheric temperatures is the rhombic form, which is soluble in carbon disulphide and in a number of organic liquids, but insoluble in water. A considerable number of boiling-point determinations in different solvents (see especially Aronstein and Meihuizen, *Arch. néerland.*, 1900 [ii.] *3*, 89–130) have shown that the molecular weight of soluble sulphur corresponds at all temperatures with the formula S_8. Freezing-point determinations, using melted phosphorus as solvent (Gloss, *J. Physical Chem.*, 1898, *2*, 421–426) gave the values $M=259$ for rhombic sulphur and $M=260$ for prismatic sulphur, agreeing closely with the figure $M=256$, calculated for the formula S_8. This formula may therefore be assigned without hesitation to the variety of sulphur which is soluble in carbon disulphide, whatever form the crystals may assume—rhombic, prismatic, nacreous or tabular.

"Insoluble Sulphur."—When sulphur is heated to fusion it yields at about 120° C. a clear liquid which recrystallises readily in the prismatic form. But if the heating be continued it darkens in colour and becomes viscous, almost suddenly, at a temperature of about 160° C. The viscosity reaches a maximum at 180°, diminishing somewhat from that temperature to the boiling-point, but the liquid remains dark and never becomes really mobile again. When the liquid is quenched in water, the product is found to be in part insoluble in carbon disulphide; the proportion of insoluble sulphur is small when the melt is quenched from a temperature near its freezing-point, but is greatly increased at higher temperatures. If quenched from a temperature near the boiling-point the product is a stringy, viscous mass known as *plastic sulphur*; this material cannot be extracted satisfactorily with carbon disulphide until it has solidified, but is then found to consist largely of insoluble sulphur. The residue of "insoluble sulphur" left after extracting with carbon disulphide in the cold dissolves only to a very slight extent in this liquid, but its solubility is increased by

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[1] The papers referred to are: "On Amorphous Sulphur," I. Smith and Holmes, *Zeit. physikal Chem.*, 1903, *42*, 469; II. Smith, Holmes and Hall, *J. Amer. C. S.*, 1905, *27*, 797; III. Smith and Holmes, *ibid.*, p. 979; IV. Carson, *J. Amer. C. S.*, 1907, *29*, 499; V. Smith and Carson, *Zeit. physikal Chem.*, 1907, *61*, 200; VI. Smith and Brownlee, *Zeit. physikal Chem.*, 1907, *61*, 209; VII. Smith and Carson, *Zeit. physikal Chem.*, 1911, *77*, 661.

the presence of soluble sulphur. When freed from soluble sulphur, the insoluble variety is fairly permanent, and may persist for some months or years, but ultimately reverts to the soluble form.

Influence of Catalytic Agents.—The method of preparing insoluble sulphur by heating the melt and chilling with water or ice is only valid when traces of acid substances are present. As ordinary sulphur usually contains sulphur dioxide, the insoluble variety is generally produced by the treatment described above; but when this gas is expelled by prolonged heating at 448°, or shorter heating in vacuo, by freshly recrystallising the sulphur or by washing it with water, the amount of insoluble sulphur is greatly reduced. Chemical methods of removing the gas, by leading in hydrogen sulphide, or ammonia, are even more efficient, and destroy completely the power to produce insoluble sulphur; this can, however, be restored by the addition of sulphur dioxide, sulphuric acid, the halogen-acids, or phosphoric acid. Measurements of solubility, boiling-point, and density, and observations on viscosity, have shown that these substances have no permanent influence on the nature or composition of the melt, but that the alkalis act by accelerating the interconversion of the two forms of sulphur; the insoluble form is therefore produced very quickly but reverts equally quickly to the soluble form and cannot any longer be "fixed" by chilling.

Proportion of Insoluble Sulphur in the Melt.—The proportions of insoluble sulphur retained after chilling were determined by allowing the (more or less plastic) product to solidify, and then extracting it in the form of a fine powder with cold carbon disulphide. The following figures were obtained:—

Temperature of chilling	150°	165°	220°	310°	448°
Insoluble sulphur.........	6·7	14·0	29·4	32·6	34·1%
Ditto (with iodine)......	13·8	24·1	47·0	54·2	62·7%

At the lower temperatures probably the whole of the insoluble sulphur is fixed by chilling; at higher temperatures there is certainly a great deal of reversion to the soluble form, *e.g.*, a stream of *burning* sulphur (amply provided with sulphur dioxide!) quenched in ice-water, gave as much as 51% of insoluble sulphur, where quenching in the ordinary way gave only 34%. The addition of iodine, unlike that of sulphur dioxide, not only facilitates the fixation of the insoluble sulphur, but produces a large increase in the quantity available in the melt for fixation by chilling; the figures for sulphur containing 2% of iodine are shown in the last line of the table, and further increases are produced in presence of larger quantities of iodine.

Influence of Insoluble Sulphur on the Freezing-point.—Insoluble sulphur dissolved in soluble sulphur acts as a foreign substance in lowering the freezing-point of the melt. This lowering takes place whichever variety of sulphur is persuaded to crystallise out. The following table shows (1) the "ideal" freezing-points of three of the crystalline forms, when separating from a melt consisting wholly of the soluble form, *e.g.*, from crystalline sulphur recently fused in presence of sulphur dioxide; (2) the "natural" freezing-points of the same three forms, when the melt contains the normal proportion of the insoluble variety shown in the last column, a condition that is very quickly produced in presence of ammonia.

	Ideal Freezing-point.	Natural Freezing-point.	Insoluble Form.
Prismatic Sulphur[1] S_{II}	119·25°	114·5°	3·6%
Rhombic Sulphur[1] S_{I}	112·8	110·2	3·4
Nacreous Sulphur S_{III}	106·8	103·4	3·1

Molecular Weight of Insoluble Sulphur.—When the proportion of insoluble sulphur in the melt, and its influence on the freezing-point is known, it is not difficult to calculate its molecular weight. The actual value deduced by Professsor Smith was 7·75 atomic proportions, a value that agrees closely with the formula S_8 deduced for the vapour below the normal boiling-point, and for the soluble variety of sulphur. The equilibrium in the liquid, which is represented by the scheme $S_\lambda \rightleftarrows S_\mu$, is therefore an example of dynamic isomerism.

Dynamic Isomerism in Liquid Sulphur.—In this scheme S_λ represents the light-yellow molten soluble sulphur, whilst S_μ represents the dark, viscous variety, which solidifies to insoluble sulphur. Plastic sulphur is an over-cooled liquid mixture or solution of the two forms, and solidifies to a mixture of soluble and insoluble sulphur. The most remarkable feature of the isomerism is an abrupt change at 160°, which is shown by a sudden increase of viscosity and a marked absorption of heat when this temperature is reached. At this temperature also the coefficient of expansion of the melt passes through a sharp minimum. Its solubility in triphenylmethane, which increases rapidly up to 150°, decreases rapidly from 200° upwards; there would, therefore, probably be a sharp maximum at about 160° if a solvent could be found with which the sulphur did not become completely miscible. These abrupt changes point clearly to the appearance of a new "phase." It is suggested that the insoluble sulphur accumulates in the limpid melt of S_λ up to 160°, when saturation is reached and the insoluble form separates as a second liquid layer of S_μ. The melt then consists of an emulsion of S_λ and S_μ, the former consisting mainly of soluble sulphur and the latter mainly of the insoluble form. To the presence of two such phases in the liquid, the extreme viscosity of the mass is very possibly due.

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[1] These two names are interchanged in the German paper, and in the Abstracts and Annual Report of the Chemical Society; the correction made above has been confirmed by a personal letter from Professor Smith.

The British Association.—The forthcoming meeting of the British Association at Dundee, opening on September 4th and of which we have previously noticed some of the chief papers to be read before the chemical section, promises to be one of unusual interest.

PROBLEMS IN TECHNICAL EDUCATION.[1]

By PROFESSOR J. PERRY, D.Sc., F.R.S.

WE no longer question the importance of Technical Education. Everybody acknowledges that unless facilities are given for education in the scientific principles underlying industries, these industries must decay. But a great deal has yet to be done to induce our governing men to give practical effect to the general wish, and so we must now debate as to details, the general principle being established.

I myself believe that education of workmen is more important than anything else. Some of my friends believe that money spent on evening classes is all wasted, and that only the education of the leaders of industry ought to be attended to. Both views are being developed, and this is an excellent time for the discussion of the problems which have to be solved.

The older and also the more numerous new universities are now fitted with commodious buildings and apparatus and staffs of teachers for giving instruction in Natural Science and the application of scientific principles for the service of man. But the schools do not yet prepare boys for such studies. At schools there is an unsympathetic atmosphere for such studies. The schoolmaster still calls the average boy a stupid boy, and does not recognise that for such boys the best mental training is through observation and experiment. In spite of the great success which has been met with in some schools in the teaching of natural science and reformed methods of teaching mathematics, science undergraduates of over 19 years of age have still to spend two valuable years in learning elementary science, which they ought to have known at the age of 14, and they are still quite unacquainted with the use of most necessary mathematical tools. A knowledge of scientific method and sympathy with scientific discovery can never come to such students; it is too late.

A drastic reform of the schools is necessary. It is also necessary to greatly lower the age for entrance to the university and to completely alter the character of the entrance examination.

The poor qualifications of the undergraduate have already given a feeble character to the university teaching; instead of giving a scientific knowledge of principles, the teacher can only aim at producing the perfect formula engineer. Consequently, in America the old three-years' course has become a four-years' course, and even a five-years' course; but it may with confidence be predicted that even a twenty-years' course will prove too short for the production of this kind of perfect engineer. I believe that the University College has been attempting two tasks with which it ought to have nothing to do; first, the teaching of elementary science; second, the production of the complete engineer. The first of these is the business of a school, the second is the business of the engineer's office and the factory.

Some colleges of university rank are giving so-called post-graduate professional courses of instruction to advanced students. Such courses are a snare. For one thing, they keep our men so long at college that they become stale. But I can imagine a useful professional course of ten or fifteen lectures on some important subject, to be given in the evening; not to college students, but to young engineers in practice. They would also no doubt attend the meetings of the Institution of Civil Engineers and other professional societies.

I would now speak of the problems of the Technical Colleges. Many of these colleges have cost hundreds of thousands of pounds. When a great donation is made, it is usually spent in new buildings, and creates the need for more money, so that the school is always in want. Economy through the cutting down of salaries is always obvious and easy, and therefore it is that we have magnificent buildings and fine apparatus, and an inadequate supply of half-paid teachers. It is forgotten that for the first time in the history of the world we intend to study the minds of our students, to find out how each student ought to be taught: our ideas are antagonistic to crystallised labour-saving systems, and yet we give salaries that can be accepted only by self-sacrificing enthusiasts or by wooden-headed men who can find no other work to do except to turn the handle of an educating machine. Another way to get enough money is to increase the fees of students. This is bad, but it is not so bad as the other. The best students for the day classes of the Technical Colleges are the sons of men who have incomes of from £200 to £400 a year, and who have to be very economical in bringing up large families. These are the boys who are most enterprising and enthusiastic in their work. They cannot pay even so much as £10 per session. Scholarships help only 5 % of such boys, for scholarships always go to the exceptional boys, who are fond of abstract reasoning, or who have good memories. The other boys, usually said to be stupid, but who are really likely to be the cleverest men, have no chance of scholarships.

I will now leave this question of false economies. I believe that these colleges ought to imitate the Finsbury Technical College, taking boys of 15 or 15½ as day students for a two-years' course; giving them such a training in science that when they go to business or enter works at 18 they will quickly understand what is going on, and learn the business quickly. The Finsbury experiment has been thoroughly successful. The students are still so young when they leave Finsbury that they are quite teachable in the factories; if they were older they would not possess that modest opinion of their attainments which causes workmen to take an interest in teaching them. Also they would probably be unwilling to do dirty, rough work, hurtful to their hands and their appearance. As I have said, the Finsbury experiment has been successful. The difficulty which is met with almost everywhere is due to the fact that the schools do not fit boys for such a course, and magnificent colleges which might have two or three hundred day students have only ten or twenty.

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[1] Delivered before the British Science Guild on March 11th, 1912.

Such colleges, with only a very few day students, have often many thousands of evening students, apprentices in mechanical, electrical, building, and other kinds of engineering. These apprentices at about 15 or 16 years of age, have now many inducements to attend science classses. They left their primary schools at 13 or 13½; they never knew much, and they have had time to forget what they once knew, and therefore for two years in evening science classes they are only learning elementary things which they ought to have known already. They not only waste the time of a well-trained staff, but they waste that time of their life in which enthusiasm and energetic work might be possible. As a rule, at the end of four years' evening work they are still engaged on very elementary studies, and are getting tired of all study.

I consider that the thorough use of our University Colleges and our Technical Colleges for day and evening work, by properly prepared pupils, would effect an enormous improvement in English industries and in the happiness of the people. But this is not possible until we have a school reform. An apprentice at 14 ought to be able to do mensuration and easy computation, arithmetical and algebraical; he ought to be able to use drawing instruments; he ought to have an exact knowledge of simple physical principles gained from his own experiments; he ought to be fond of reading. Perhaps the power to write a letter, and a fondness for reading books are of more importance than anything else.

Again, for the undergraduate and the day student of a Technical College, I would place a knowledge of English and fondness for reading as more important than all other qualifications, for a man who is fond of reading educates himself during his whole life. Unless one reads the evidence of Lord Roberts before the War Commission, he will hardly believe that nineteen-twentieths of our public school boys should be so illiterate as they are, and my recommendation therefore means a great reform. The mind of the average boy gets no school training at the present time, and I think that his is almost the only kind of mind that needs training.

A boy at 14½ fit to be an apprentice will attend evening classes and day classes if he gets time, till he is 20. If he is exceptionally clever, he could now have a whole session at day work only. Such a man has finer chances as an engineer than any other man I can think of. It is for the sake of such a man that I desire to have some very advanced day courses of instruction in Technical Colleges.

Again, the more well-to-do boy, who, after a two-years' course at a Technical College in the daytime, enters works for 2½ or 3 years, will, if it is good for him (and he himself will be the best judge as to whether it is good for him), take a year of advanced scientific work before he settles down to his profession. He will not have the same chance as the poorer boy of becoming a good workman, but his longer schooling may possibly fit him better for the higher posts. It ought, however, to be always understood that his worth greatly depends upon the practical shop experience he has.

As for the university man who has had fit preparation at school, who enters the university at 17 and leaves at 20, he will have worked with enthusiasm, and will be well acquainted with the scientific principles underlying his profession. But much more than the men of the other two classes, he will have qualifications for leadership. He has had a liberal education, not through Latin and Greek, but through contact with great men; through his love for English literature and Natural Science, and from having a more refined home life. Still, it must be remembered that it is not until he has had some years' professional experience in some kind of work which he loves that he begins to be an engineer. He cannot hope to make a salary he can live upon till he is more than 25 years of age.

For all three classes of men it is important that no stupid barriers should be placed in their way; there must be no discouragement from the necessity for passing examinations in non-essential obligatory subjects, such as often destroy our best men. Some men take kindly to modern languages; give them every encouragement and all facilities. Some men have no fitness for learning French and German; why compel them to take up studies which do not interest them, if they are not essential?

The object of a matriculation examination is to test whether a man is likely to benefit by attendance at any of the courses of study of the university, and entrance ought to be easy. The individual professors ought, however, to have the power to prevent unqualified men from attending their courses. There is hardly any business in which it is not essential to have a knowledge of English, a knowledge of computation, and a training in experimental Natural Science, and success is hardly possible for any man who does not love books. Here we have qualifications which are essential for entrance to all science courses of study, and for entrance into 90% of all the skilled industries.

International Association of Leather Trades Chemists.—A Conference will be held in London from September 16th to 20th, 1912, under the presidency of Dr. J. Gordon Parker, F.I.C. The reception of members will take place on the 16th at the Leathersellers' Hall, at 10.30 A.M., to be followed by a luncheon at the Trocadero. Technical meetings will be held on the 17th, 18th and 19th, at the Leathersellers' Hall. Mr. M. C. Lamb is acting as Hon. Organising Secretary.

THE FOOD PRODUCTS OF RHODESIA.

By Loudon M. Douglas, F.R.S.E.

It is probable that Rhodesia may become in the near future one of the important food exporting countries of the world. It may be some time yet before such a position is attained, but, if the farming community continues to increase as at present, there can be little doubt as to the ultimate result. Rhodesia is a vast territory covering an area of 750,000 sq. miles, which is larger than Germany, France, Switzerland and Austria all put together. It is to the southern portion of Rhodesia, however, that attention is being particularly directed at the present time, and the great plateau which extends between the Zambesi on the north and the Limpopo on the south is being rapidly developed as a food producing area. The extent of this area is 192,000 sq. miles, with average altitudes of from 3,000 to 6,000 ft. above the sea-level, and its importance may be recognised when it is considered that the white population numbers 23,606, whereas in the whole of Northern Rhodesia the white population is only 1,497. It is interesting to notice that in Southern Rhodesia, alongside of the white population, there is a population of 771,077 natives. In Northern Rhodesia there are 822,599 natives. These facts are singular as they show that the settler has located Southern Rhodesia, at least in the meantime, as being the best suited for farming and pastoral pursuits. Coincident with this, it may be recognised that the principal mining industries in Rhodesia so far are those which have been developed in Southern Rhodesia, the potentialities of the great northern territory being yet comparatively unknown.

A Field of Oats near the Matopos Hills, Southern Rhodesia.

It will be remembered that Rhodesia is administered under a Charter granted by the British Government to the British South Africa Company in 1889, which was subsequently amended in Council in the years 1894 and 1898. The administration is at present vested in the Chartered Company, and is exercised by an Administrator, appointed by the Company, with the approval of the Secretary of State, and who is supported by an Elective Council. Under such conditions the country has made rapid progress in the development of its natural resources, and the mineral wealth produced has been enormous. Systematic agriculture, however, and the growth of food products, is only of comparatively recent origin, with the result that the farms at present have not yet settled down to regular methods of agriculture, owing to the fact, perhaps, that the rich virgin soil has enabled them to produce mealies or Indian corn very easily, and there has been no necessity for studying such questions as the rotation of crops. The Kaffirs in Mashonaland grow a mixed crop of mealies and rapoko (*Eleusine coracana*), which is a kind of Kaffir corn, but their object seems to be to provide against the probable failure of the crop of mealies. This is indeed one of the unfortunate features of the country which has to be reckoned with, namely, the probability of drought and the consequent failure of the maize crop. Thus in the year 1911 "the average maize crop, particularly on red soil, was reduced by at least 10 to 15% by these droughts, and the late rains did considerable damage, both to tobacco and maize, while a large proportion of the native crops, in particular rukwedza (*Eleusine coracana*), were also injured, and but little Kaffir grain has therefore been available for trade."[1]

SHELLING MEALIES IN A NATIVE KRAAL, SOUTHERN RHODESIA.

The rainfall throughout the country is not equally distributed and is greatest in the higher altitudes, such as in the Melsetter district, but the most unfortunate part of it is, that the rain comes all in the few months from October to April and then supervenes a considerable spell of dry weather from May to October. These climatic conditions have recently been the subject of considerable study, and it would seem as if insufficient attention has been given in the past to the moisture-retaining soils, which are abundant throughout the country. The heavy soils, through their hygroscopic character, undoubtedly hold moisture much longer than the open sandy soils, and it would therefore seem to be the correct policy for farmers to carefully select heavy soils, more especially for winter cereals. In this way there is little doubt but that winter cereals such as wheat, oats and barley, could be grown in great abundance. In some parts of the country, in fact, this has been amply demonstrated, and now that rust-proof varieties of these cereals can be obtained, there is little doubt but that the luxuriant climate which Rhodesia possesses, will enable them to be extensively grown.

As has been pointed out, systematic farming has hardly developed to any great extent in Southern Rhodesia. A "farm," to begin with, usually consists of from 1,500 to 6,000 acres, and only a small portion of this area is allotted to cultivation, the remainder being devoted to grazing. So far, there has been little call for the use of artificial fertilisers, owing to the richness of the soil, but this richness is bound to become exhausted in the near future and it will then be a problem how the soil has to be renovated. There is plenty of power in the Victoria Falls to make sufficient nitrate of lime to supply the wants of all the farms in existence in Rhodesia, and a great many more, but the absence of lime itself from the soil, makes it somewhat difficult to grow certain crops. Thus, in the growing of lucerne, it has been found difficult, except in certain areas where lime exists, to grow this plant profitably. On the other hand, such a grass as Paspalum (*Paspalum dilatatum*) has proved to be a valuable winter pasture, more especially on red soils. The best results, however, have been obtained, as might be expected, on moisture-holding soils.

In the following table are given analyses of various cereals and food products grown in Rhodesia, the samples being taken from 1911 produce:—

ANALYSES OF VARIOUS CEREALS AND FOOD PRODUCTS GROWN IN RHODESIA.

Samples from 1911 Produce.

—	Dry Matter.	Ash.	Protein.	Fat.	Fibre.	Carbohydrates by Difference.
Horse Tooth Maize	89·55	1·20	10·01	4·61	1·89	71·84
French Beans ...	88·35	3·11	20·56	1·10	3·84	59·74
Speckled Beans ...	89·30	3·04	28·42	0·76	3·89	53·19
Small Haricot Beans	89·70	2·70	33·34	0·75	3·93	48·98
Kaffir Corn	89·95	1·38	10·59	2·17	1·93	73·88
Munga	92·15	2·09	12·23	4·27	1·50	72·06
Rapoko	90·15	2·20	6·50	1·26	2·89	77·30
Red Beans	89·15	3·10	21·67	0·84	3·78	59·76
White Peas	90·10	2·68	25·73	1·01	5·33	55·35
Wheat	89·65	1·39	14·23	2·33	2·61	68·09
Barley	89·45	2·16	12·13	1·55	6·90	66·71
Native Rice... ...	90·40	5·30	8·40	1·32	11·39	63·99
Manna	90·85	2·65	11·94	2·73	7·67	65·86
Dried Green Peas ...	89·05	2·66	20·49	0·60	6·17	60·03
Large Haricot Beans	90·25	4·05	24·71	0·90	5·37	55·22
Large Flat White Maize	90·20	1·18	11·80	3·40	1·91	71·91
Yellow Maize ...	90·15	1·94	11·80	3·12	1·58	71·71
Native Beans ...	91·00	3·19	19·74	6·34	4·07	57·66
Buckwheat	88·80	2·11	10·96	2·05	11·90	61·78
Velvet Beans ...	90·40	2·58	27·30	5·81	7·99	46·72
Sunflower	90·15	3·00	16·84	28·65	32·02	9·64
Monkey Nuts ...	93·45	2·18	28·90	44·08	4·12	14·17
Linseed	93·35	3·61	23·51	28·20	5·82	32·21

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[1] Report of the Director of Agriculture for Southern Rhodesia. Presented to the Legislative Council, 1912.

The foregoing represent the principal food crops grown in the country, the greatest product being maize. The other food products vary in quantity very considerably, but they have been all shown to be capable of extensive cultivation, and in the near future it is hoped that a considerable surplus of many of these products will be available for export. In the meantime, the only one amongst them which has been exported to any extent is maize, and it is stated that the recorded figures for maize for 1911 are 393,166 bags, an increase of 758% in seven years. Of this, 307,635 bags are credited to Mashonaland, and 85,531 bags to Matabeleland. The growth of the export trade in maize is instructive, not for any stupendous figures, but as showing a steady increase, in spite of fluctuating local market conditions, and as demonstrating the commercial value of the facilities arranged for export and disposal in the European market :—

SHELLING MEALIES BY STEAM POWER ON THE VELDT.

EXPORTS OF MAIZE (MEALIES) FROM RHODESIA.

Year.	Quantity. Lbs.	Value. £
1907	27,308	95
1908	53,847	246
1909	2,288,453	6,023
1910	5,911,123	11,973
1911	8,272,553	16,878

"The yield of maize per acre was considerably lighter than in the previous year, and generally fell short of expectations."[2]

The principal problem so far, has been the supply of local wants and the feeding of live stock has especially, been greatly studied from the point of view of finding a proper ration to suit milking cows, calves, fattening bullocks and fattening pigs. The growing of sheep in Rhodesia is not at present a serious question, owing to the fact that it has not yet been determined which breed of sheep is most suited to the climate of the country.

The table of analyses shows a very high percentage of starchy matter in the majority of the cereals and, from the stock-feeder's point of view, this is a serious drawback, starchy foods alone being considered of poor value for feeding purposes. It has been suggested that the following rations might suitably be given to cows, bullocks and calves :—

RATION NO. 1, FOR COWS.

Kaffir Corn, Munga or Rapoko	3
Maize (mealies)	2
Monkey Nuts	1
Beans	2
	8

Ratio 1 : 5

RATION NO. 2, FOR FATTENING BULLOCKS.

Kaffir Corn, Munga or Rapoko	3
Maize (mealies)	3
Monkey Nuts	1
Beans	1
	8

Ratio 1 : 5·6

RATION NO. 3, FOR FEEDING CALVES.

Kaffir Corn, Munga or Rapoko	3
Maize (mealies)	3
Monkey Nuts	1
Linseed	1
	8

Ratio 1 : 5·9

(*To be continued.*)

MEETING OF SCIENTIFIC AND TECHNICAL SOCIETIES IN CORNWALL.

A FEELING has often been expressed that the regular summer and autumn gatherings of our societies are either somewhat limited as to variety of type among the men who attend them, as in the case of such excellent meetings as those of the Iron and Steel Institute, the Society of Chemical Industry, and the Institute of Metals, or (where varied pursuits are more fully covered) are overwhelmed by numbers as is noticeable at the meetings of the British Association or of the Congress of Applied Chemistry and other similar functions.

The difficulty which members of one Institution always experience in getting into touch with those who are of similar tastes, but work in different branches of science or technology, becomes emphasised by such meetings where old friends constantly congregate, but where opportunities for making new friends and exchanging broader views are exceptional.

At the Cornwall meeting, where numbers were limited and variety enforced, the conditions were almost reversed. It is true that old friends met, but those who were invited found it a chance, such as has never before been afforded, of infusing new blood into their mental arteries and of supplying some of their own to others equally in need of an antidote to the actual, though seldom admitted, mental inertia from which scientific and technical circles will continue to suffer until their ideas are considerably widened.

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[2] Report of the Director of Agriculture, 1912.

Such a reproach cannot be made as regards the scheme which culminated in the meeting in Cornwall, and it is pleasing to note that the result was by no means accidental. It was the outcome of the carefully thought-out programme of a Committee formed in Cornwall for the express purpose of inviting certain members of Council and officers of the principal Scientific and Technical Societies to meet other representative men under ideal conditions, and at the same time, learn more of the mining and engineering industries of the oldest mining district in the British Empire and the premier mining district of the world, if one considers the continuity of its work since the time of the Phœnicians.

A glance through the names heading the excellent programme of 100 pages, which was presented to each guest, shows how well qualified was the Committee to carry out its object. Historical names are plentiful and, although the three Cornwall societies who have done so much in the past in the development of the mining and engineering industries of this country, and incidentally of the whole world, wisely decided to merge their individuality, all were fully represented and the party had every reason to feel that they were the guests of Cornwall in the fullest sense of the word. So well was the idea carried out, that the guests were distributed at the hotels facing the bay of St. Ives, to which they returned after the day's visits were completed, in such manner that each was compelled—willingly enough but often unexpectedly—to spend the evening and exchange ideas with new men, instead of platitudes with old friends.

That the Committee and its energetic Secretary, Mr. E. W. Newton, to whom the success of the meeting was so largely due, made the selection best calculated to further their desire to bring together those who ought themselves to have initiated such a movement years ago, is shown by the fact that among other societies, etc., representatives were gathered together from the Royal Society, Geological Society, Geologists Association, Chemical Society, Faraday Society, Society of Chemical Industry, Society of Public Analysts, Institution of Mining and Metallurgy, Institution of Mining Engineers, Institution of Civil Engineers, Institution of Mechanical Engineers, Institution of Electrical Engineers, Institute of Chemistry, Institute of Metals, Iron and Steel Institute, Chemical, Metallurgical, and Mining Society of South Africa, Mining and Geological Institute of India, representatives from the Birmingham, London and Sheffield Universities, the Imperial College of Science and Technology, and the Imperial Institute, etc.

The number of guests representing these institutions was limited to seventy. The total attendance, including local guests and Committee men was limited to one hundred, and the invitations were so allocated that a more *representative* gathering was secured than has ever before been collected together even at Congresses numbered by thousands.

The visits, which extended over five days, included journeys to the Dolcoath, South Crofty, King Edward, Trenwith, St. Ives Consols and Giew Mines, the engineering works of Holman Bros., and R. Stephens and Son, the Safety Fuse Factory of Bickford, Smith & Co., the Hayle Electric Power Station, the China Clay works of Messrs. Parkyn and Peters, and the alluvial tin deposits of Redmoor. Trips to St. Michael's Mount, the Sub-Tropical Gardens of Mr. H. Fox, a special journey down the Fal and visits to the museum of the Camborne School of Mines and that of the Royal Institution of Cornwall, a call at the headquarters of the Royal Cornwall Polytechnic Society, official lunches and unbounded personal hospitality at the various mines and works which were visited, enabled the visitors to learn much of the social in addition to the business side of Cornwall.

Although the result of the visit cannot fail to open the eyes of the guests to the possibilities of Cornwall, there was a pleasing absence of anything of the nature of personal advertisement, and the official and other speeches, to which representatives of all the institutions were enabled to contribute through the careful arrangement of the toast lists by the Secretary, showed only a desire on the part of all to receive and impart information on the many debatable points which exist in Cornwall as in all mining districts, as to means for increasing the recovery of mineral values and for generally improving the prospects of a mineral area, whose future compares well with most of those abroad, and which can be developed under conditions more favourable than are met with elsewhere.

From the educational point of view, the visit is likely to prove of far-reaching importance. The Duchy, under the guidance of the Royal Cornwall Polytechnic Society (which was founded in 1833, and for which the word Polytechnic was coined) was the first society in the world to actively interest itself in the training of artisans, and has always formed an important recruiting ground for mining men and engineers. The names of Davy, Watt, Trevithick and Murdoch may be mentioned among scientists and engineers, while a host of names representing the pioneers of mining enterprise throughout the world might be included. Cornwall possesses in the King Edward Mine the only mine which is worked on a commercial scale for the training of students. With its dressing floors, drawing office, workshops and laboratories, surrounded by other producing mines to which all have free access and in the heart of one of the most highly mineralised districts in the world, it forms an ideal place for training miners, geologists and mineralogists and for mechanical engineers, interested in mining machinery, and even for the large and increasing body of students who intend to devote themselves to mineral chemistry.

The suggestion has been made that the school—known as the Cornwall School of Metalliferous Mining—should be affiliated with the Royal School of Mines of London, or become a part of the Imperial College of Science and Technology, of which the Royal School of Mines is an integral part, and it is to be hoped that the knowledge gained by the visitors—whose direct and indirect influence in this direction will be all-powerful if they work together—may result in its consummation.

The needs of the Cornish School, although considerable, are largely financial, but the necessities of the London student are even more pressing. The present provision for his practical training is now being carefully considered, with a view to its entire revision, and the suggested amalgamation would probably furnish a satisfactory solution.

GEORGE T. HOLLOWAY.

Congress of Mathematicians.—Opened at Cambridge on the 21st of last month. Lectures were delivered by Professor M. Bocher, Professor E. Borel, Professor E. W. Brown, Professor F. Enriques, Prince Galitzin, Professor Sir J. Larmor, and Sir W. H. White. The Chancellor (Lord Raleigh) attended, and held a reception in the Fitzwilliam Museum the following Friday.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By EMIL HATSCHEK.

CHAPTER VII.—(*Continued*).

ANOTHER feature of great interest has been investigated chiefly by the present writer. By choosing suitable concentrations of the gel itself, and of the reacting salts, most of the insoluble precipitates in the gel can be obtained in very large crystals; in many cases, as with lead chloride, lead sulphate, lead chromate, lead iodide, calcium sulphate, barium silico-fluoride and others, they are of microscopic size. Many compounds also show a marked tendency towards the formation of spherical aggregates and perfect spherolites, giving the well-known appearance between crossed Nicols, are frequent. Figs. 11 and 12, for instance, show calcium sulphate obtained in two different gelatine gels, magnified 100 diameters. Calcium sulphate obtained by reaction in aqueous solutions of similar concentration forms fine needles, which, on the same scale would appear 3 to 5 mm. long.

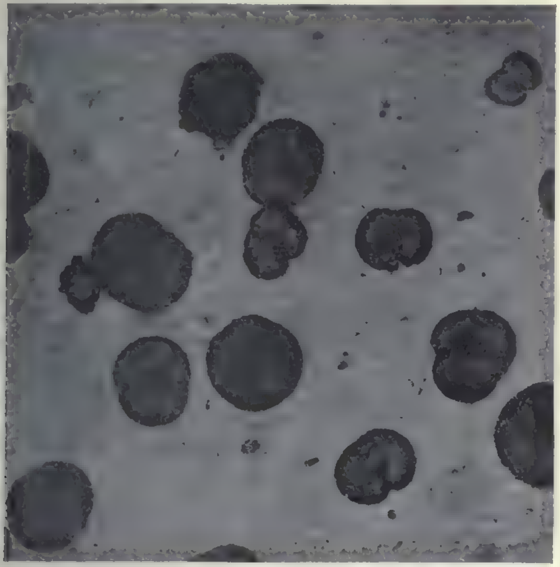


FIG. 11.

These results show that large aggregates of very insoluble substances can be formed by reactions in a gelatinous medium in comparatively short times; they thus throw considerable light on many questions of physiology, pathology and geology, detailed discussion of which, however, is beyond the scope of these articles.

CHAPTER VIII.

WE have already had occasion to emphasise the importance of the large boundary surface between the phases of a disperse system, inasmuch as it influences its electrical properties and, in the case of two liquid phases, its viscosity. We now have to consider a very large and very varied class of phenomena, in which this surface is the determining factor, all of which may be comprehensively described as changes of concentration in one phase at its boundary surface with another phase.

Many instances will be familiar to the reader, either from text-books or from actual use. Such are, for instance, the capacity of charcoal to condense large volumes of gases, of which advantage is taken for obtaining extremely high vacua. A similar property of charcoal, that of taking out of solutions colouring matter or the higher alcohols constituting "fusel oil," has been known since the end of the eighteenth century and is used industrially on a very large scale; china clay and fuller's earth are also employed for purposes of the same kind. Another phenomenon of the same description is the power possessed by certain gels, such as gelatine and isinglass, of taking down turbidities in organic solutions. An instance familiar to the analyst is the well-known fact that the concentration of many solutions, *e.g.*, of lead salts, is considerably reduced by filtration through paper, that is, by contact with cellulose fibre.

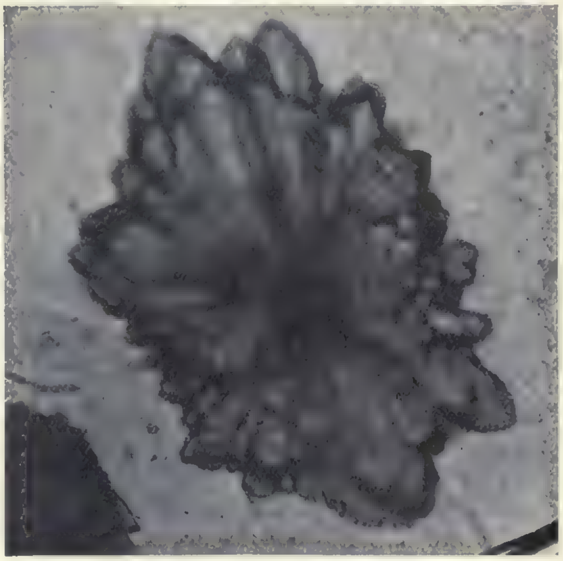


FIG. 12.

This list could be extended very largely, but the instances given are sufficient to show that in all cases the effect is produced at a boundary surface of considerable extent; charcoal, clay, and even more strikingly the gels are all characterised by a very large surface development. Certain substances in solution are concentrated at these surfaces, and this change in concentration is now generally called adsorption.

The occurrence of these changes at surfaces also provides us with the clue to their investigation. We have already, when discussing emulsions, referred to the fact that the surface of a liquid against its own vapour, or against a second liquid, is in tension, known as surface tension in the former and as interfacial tension in the latter case. This tension is an extremely well-defined physical constant, and can be measured by a great number of methods. For details of these the reader must be referred to the text-books of physics or physical chemistry; they all depend on the tendency of the surface tension to reduce the surface and to establish equilibrium with the other forces acting on the body of liquid under examination. As it takes work to produce or to enlarge a surface, it is, when formed, the seat of energy, which is measured by the product of surface and surface tension per unit length, and which, of course, tends to become a minimum. We already know of one way in which this may be accomplished, viz., by the surface becoming a minimum; thus a drop of liquid suspended in another of the same specific gravity assumes spherical shape, the sphere having the minimum surface for a given volume. Obviously this is possible only where both phases are easily deformable, *i.e.*, when both are liquid, or one liquid and the other gas.

The question now arises, whether such tensions and energies also exist at the surfaces gas-solid and liquid-solid, especially in view of the instances quoted above, all of which refer to such systems. It is obvious that the immediate methods of demonstrating and measuring such tensions, as applied to easily deformed phases, fail, since the surface of the solid is not easily altered and does not adjust itself to the tension. We can therefore only conclude by various inferences, which cannot be gone into here, that such tensions do actually exist, and the evidence on this point is quite conclusive. The question then arises, whether the surface energy at the boundary of a solid is a constant for a given system, or whether by some means it can assume a minimum value. Since it is the product of the surface tension into the surface, it can, of course, be reduced by reducing either factor; in the case of a solid the second one, the surface, is fixed, and any reduction which may occur must be due to a decrease in the first factor, the surface tension. It is at least a reasonable assumption that a change in concentration at the boundary surface *may* be accompanied by such a reduction; if this assumption is correct, such a change ought to take place, and this is what actually happens.

We have thus come to the conclusion that, if in a two-phase system a change in the concentration of the liquid or gaseous phase will lead to a decrease of surface energy, this change will occur; to prove this view we have to investigate whether in all cases where such changes appear there is a diminution of surface energy. A change of concentration can occur in a gas, if it is compressed at the boundary surface, or in a solution, if the dissolved substance is accumulated at the surface. Now we know that charcoal, for instance, does condense gases on its surface, or takes colouring matter out of solution, but, as already pointed out, we have no means of measuring the surface tension. We must accordingly get evidence by studying similar phenomena under conditions which permit such measurements, and this is possible by investigating the behaviour of a mercury surface against gases. The subjoined table gives the surface tension of mercury against vacuum (*i.e.*, its own vapour only) and various gases, one value being taken immediately after formation of the surface, the other after one hour.

Atmosphere	σ (fresh surface)	σ (after one hour)
Vacuum (15°)	436	436
Hydrogen (21°) ..	470	434
Oxygen (25°)	478	432
Nitrogen (16°)	489	438
Carbon Dioxide (19°) ..	480	436
Dry Air (17°)	476	429
Moist Air)17°)	481	429

It will be seen that the two values measured in vacuo are the same, that is, no change has taken place after one hour. In all the gases, however, the final value of the surface tension is considerably lower than the initial one, and this change is accompanied by the condensation of gas on the mercury surface. The rate of change is characteristic for each gas, and curves plotted with the times and tensions as co-ordinates agree very well with corresponding concentration-time curves obtained in the case of solid adsorbent materials. As the decrease in the surface tension mercury-gas is accompanied by compression of the latter, we must at once conclude that the surface tension of mercury should be lowered with rising gas pressure—a conclusion which has been experimentally verified.

The case discussed furnishes us with an instance in which the concentration—or, in other words, the pressure—of a gas has been altered at the surface of a liquid, with a change in surface energy, and we conclude that the same conditions hold good at the boundary solid-gas. We may now consider an instance of the surface liquid-gas, in which the change of concentration takes place in the *liquid* phase, with the object of once more verifying that it is accompanied by a reduction of surface tension. We already are familiar with one simple criterion of lowered surface tension: froth formation. If we therefore take a solution exhibiting this characteristic and produce the largest possible surface, by making a froth, this ought to contain the dissolved substance in greater concentration. This reasoning has also been verified experimentally by various observers, especially by Miss Benson in the case of solutions of amyl alcohol in water, which froth copiously. Air is drawn through the solution, which carries the froth formed over into a second vessel; the latter and the bulk are then analysed separately.

(*To be continued.*)

NOTES ON CHEMICAL RESEARCH.

By The Editor.

CHAPTER VI.

Research in Relation to Analysis.

> "Every fact and every discovery casts a light beyond itself, and the extent to which this light is perceived depends upon the man."—*Gore.*

The influence of the application of modern theory to the methods of analysis has been of great importance. Until this was directly brought to bear on analysis the latter was incomplete, and to an extent empirical in its actual procedure.

Analysis was first placed upon a definite basis by Gay-Lussac and Berzelius. In the early development of chemistry, it played an important part. Regarded in latter years as an art rather than a science it ran a more or less isolated course, having little in common with the general development of theory. Rivot, Fresenius, and Rose practically limited themselves to detail in manipulation and the general conditions of working.

During more recent years this position has altogether changed. A detailed knowledge of the underlying principles of precipitation, etc., has modified the entire position, and analysis from its very nature has once more occupied an important place in its relation to the general theory. This change has been definitely described by Ostwald in "Die Wissenschaftlichen Grundlagen der Analytischen Chemie," Leipzig, 1908 (translated into English as "The Foundations of Analytical Chemistry," 1908).

By an application of the law of equilibrium to the reactions involved, the conditions under which precipitation may be complete or incomplete were made evident, and the methods to be pursued in order to bring this operation to practical completion in the desired direction were indicated. This review of the question of analysis in the light of modern theory has caused analysis in its many reactions to take to itself an altogether new significance, and play a more important part in the science of chemistry, supplying an efficient method of confirmation for theory on a satisfactory scale, in a way which is brought to the notice of all workers in science.

No more satisfactory example of the advantage of the application of theory to practice could be found. It indicates in the most definite manner the advantage of examining processes, whether they be industrial or analytical, from a standpoint of theory.

More general information may be gained on this point by studying the "Theoretical Principles of the Methods of Analytical Chemistry" by Chesnau (translated into English by Lincoln and Carnham, 1910). In this work will be found indications of further research which is still necessary. It deals with such important matters as the influence of the physical state of precipitates, upon their purification by washing, irreversible reactions, double decomposition of salts, and the general study of the reactions which are met with when regarded from the "ionic" standpoint.

Thus in its modern aspect analytical chemistry occupies an increasingly important position in the general scheme of chemistry; and influences, by confirmation or otherwise, theory, and many of the conclusions arrived at in the domain of pure chemistry.

Analytical Methods and New Processes.—The results obtained by this application of theory may be regarded as perhaps a simple form of research, and offer additional inducement to the young investigator, for his college training in theory may be of immediate value and importance. The scope of the literature on this subject is very voluminous, and a search will soon disclose some process in need of further investigation, or subject-matter for more or less original work.

A direct comparison of standard processes with others which are comparatively unknown, may naturally lead to an improvement in the latter in detail, and a confirmation of its limitations. Such work from its very nature is especially suitable for research under comparatively simple conditions, and for the general consideration of the young investigator.

A general view of the future position of analysis may be obtained by reference to the above-named books. Analysis, either volumetric or gravametric, offers a satisfactory field for research. A search for subject-matter, especially when the modern views are considered, will soon disclose directions in which further work is needed.

Many of the most important processes of to-day have been altered and modified for certain specific uses. The Kjeldahl process of estimating nitrogen may be instanced as an example.

The young analyst should always be on the look-out for possible improvements in methods. This search in itself cannot fail to make him a better worker, and give increased zest to his everyday work. The main object of such early investigation must be regarded as an educational one. The question of publication of results should not be considered by the beginner, except under expert advice. At the same time the results obtained should be assembled with the same care as if this was the object in view.

Obviously, defective, or rejected, processes of analysis, form a likely field for research. In these cases it may happen that the factors necessary to the successful working have not yet been appreciated. Such work which entails a careful search for the defects in the process may be regarded as altogether satisfactory for the student, especially if it is more or less simple in its nature and not obviously beyond the beginner's capacity.

Volumetric analysis, in particular, offers a suitable field for such attention. Much work remains to be done in connection with the indicators in simple acidemetry, as their actions are not yet fully understood. The presence of third substances may have a disturbing effect, the reason for which is not fully known.

This subject is worthy of the most careful study and consideration. So much depends upon the process of analysis resting on an unassailable basis. The experience gained is equally satisfactory in its nature and always useful. The results obtained may have a value outside that section of chemistry to which they often owe their origin.

Technical Analysis.—This is often of an empirical nature, and the investigation still to be undertaken in this direction possibly outweighs that already recorded. It is often of so involved a nature (owing to the conditions under which the processes have to be applied) that it offers special and specific difficulties. So great are these, that in certain cases, such as that of the analysis of tannins, purely empirical processes have the preference when they approach in their nature the working conditions of the industry itself. Thus we see in the case mentioned official sanction given to a process which is practically a reproduction of the working conditions on a small and easily manipulated scale. Hide, in a powdered form, is used as an absorbent, the tannin being taken up from an aqueous solution and estimated by direct weighing. The conditions of analysis under circumstances such as these are very circumscribed, and the procedure is very complicated. The details in working which have been adopted to regulate the action of the processes involved are set out in a series of more, or less, arbitrary rules which are carried out by most analysts who have to deal with the valuation of tannins and tannin solutions.

In most cases the position is studied from the point of view of certain definite results, rather than absolute values. Modern science has much to say on the question of the elaboration of these details, and to the more advanced worker this work offers a varied and promising field for research.

These processes are capable of revision and improvement by systematic examination of detail, and this is constantly in progress under international agreement, or otherwise. As in the case of the estimation of tannins mentioned, the process as it stands is open to considerable objection by the chemist, but the trade still refuses to abandon it by substitution of other methods which give results not so easily calculated in terms of their trade significance.

Thus, when the beginner selects such processes for investigation, he must endeavour to determine the nature of these incidental effects, and seek to either eliminate, or control them. They may possibly be traced to errors caused by solubility, incomplete precipitation, the presence of third substances, etc., and the investigator must determine the nature of such defects by direct observation. In this respect the latest available knowledge on the general behaviour of third substances, the causes of incomplete precipitation, or the probable solution state of the reacting bodies, must be fully considered, and wherever possible, applied to the case under investigation.

The careful analyst makes discoveries of general importance, including that of new elements, and finds a source of inspiration in such materials as flue dust, residuals, and other seemingly impossible, or unlikely products.

Power of concentration, and a training of no mean order is required in such investigation; and the results obtained under satisfactory conditions are of such definite value, that they receive increasing attention from all chemists.

(*To be continued*).

FINANCIAL NOTES.

Capital Invested in Industrial Enterprises in Germany in April–June, 1912.—According to the *Frankfurter Zeitung* of July 9th, the amount of fresh capital invested in industrial enterprises in Germany during the second quarter of 1912 amounted to 389,445 marks, as compared with 345,524,000 marks in the corresponding period of 1911. The following are the approximate amounts in marks invested in the more important branches of industry:—Electrical and gas companies, 69¾ millions; mining, foundries, etc., 48½ millions; metals and machinery, 47¾ millions; transport, 38¾ millions, electro-technical products, 27 millions; banks, 21¾ millions.

Textile, Spinning and Weaving Machinery.—The *Zentral-Anzeiger für das öffentliche Leiferungswesen* (Vienna) of July 18th, announces that the Hungarian Ministry of Commerce have sanctioned various business undertakings, among which may be mentioned:—Mez Vater und Söhne to establish a silk spinning factory with a capital of 1,000,000 kronen; the Hungarian Jacquard Weaving Company of Kispest to enlarge their works, which will entail an expenditure of 260,000 kronen; Heinrich und Haver of Erzsebetfalva, to erect lace and embroidery works at a cost of 540,000 kronen; Hungarian Arader Cotton Company, to enlarge their works at a cost of 1,300,000 kronen; the Hungarian Cotton Company of Ujpest, to enlarge their works at a cost of 1,200,000 kronen.

Manganese and Phosphate.—During the year active development of other mineral products has taken place in that part of Egypt surrounding the Gulf of Suez, and the north end of the Red Sea. Two companies are prospecting large occurrences of manganese ores on the western side of the Sinai Peninsula, to the north of Tor.

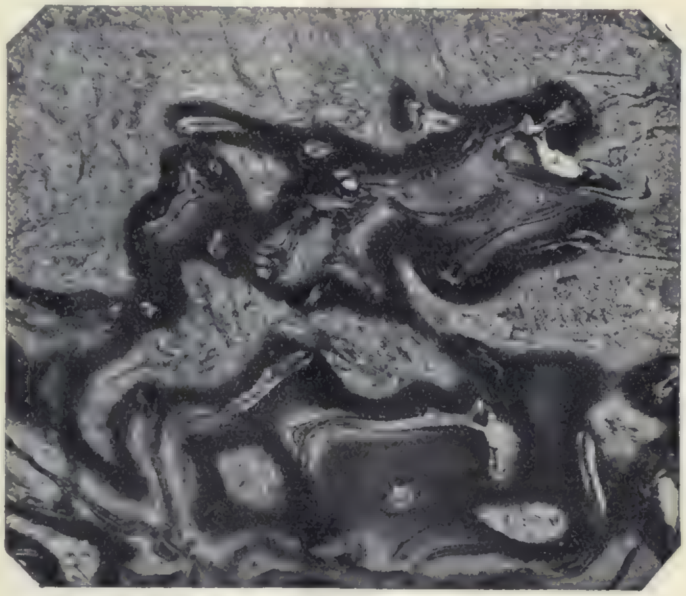
A large deposit of phosphate ore is now being worked on the western coast of the Red Sea to the north of Kosseir at Safaga. This appears to be capable of great development.

Paper-Making Plant.—A paper factory is reported to be about to instal a new machine in order to increase its output. A cellulose factory is considering the erection of paper mills. The names of the companies to which the foregoing notice relates may be obtained by British manufacturers on application to the Commercial Intelligence Branch.—*Board of Trade Journal.*

REVIEWS OF BOOKS.

"ALLEN'S COMMERCIAL ORGANIC ANALYSIS." Vol. VI. Amines, Tar Bases, Vegetable Alkaloids, Coffee and Cocoa. Edited by W. A. DAVIS and S. S. SADTLER. Contributors: W. H. Glover, T. A. Henry, F. O. Taylor, R. W. Tonkin, F. H. Carr, S. P. Sadtler, C. E. Vanderkleed, O. Chick, E. Horton, J. J. Fox, P. J. Sageman and R. Whymper. J. & A. CHURCHILL. Pages 721 + ix. Price 21/- net.

TWENTY years have passed since the last edition of this volume was issued, and the subjects treated naturally call for more extended treatment than on the previous occasion. This volume, dealing as it does with amines and other bases, such as anilines, the naphthylamines, pyridine, quinoline, etc., and the vegetable alkaloids, is likely to prove one of the most useful of the present series. The standing of those who have contributed to the different sections at once indicates that the matter contained in the same will be thoroughly up-to-date and reliable in its nature. Direct reference to the same at once shows that this is the case, and in this respect the articles by W. A. Davis on the amines and ammonium bases, the section on naphthylamine, etc., by W. H. Glover, that dealing with the vegetable alkaloids, by T. A. Henry, and the one devoted to the aconitine alkaloids and atropine, by F. H. Carr, call for special mention. The section on the chincona alkaloids, by Oliver Chick, also contains information of great value to the general analyst.



GLASSY PANTELLERITE × 30, SHOWING FLOW STRUCTURE.

The same remarks may be extended to the section dealing with caffeine, tea, and coffee, by J. J. Fox and P. J. Sageman, and also that devoted to cocoa and chocolate by R. Whymper.

While the general analyst is so dependent on text-books dealing with special branches of analysis, volumes of the character of the one under review must always have a distinct value. The present one cannot fail to serve its purpose in a satisfactory manner.

"MICROPETROLOGY FOR BEGINNERS. By J. E. W. Rhodes. LONGMANS, GREEN & CO., London, 1912. Pages 126 + xii, Chapters VII. including Appendices and Index. Numerous Illustrations. Price 2/6 net.

This volume is a practical elementary text-book on a subject which has received increased attention from students of recent years, especially as the subject is required for the Inter., B.Sc. in Geology (London). The optical properties of rock-forming minerals are treated generally, and the methods of identification of a series of minerals present in igneous rock is then discussed.

The microscopical examination of thin sections of rocks is well summarised in a final table dealing with the identification of such minerals.

A feature is the glossary index which completes this interesting text-book. This volume can be recommended to all students who require information on the subject.

"A DICTIONARY OF APPLIED CHEMISTRY." By Sir Edward Thorpe. LONGMANS, GREEN & CO., London, 1912. Vol. II., CHI—GO. Pages 786 + viii. Numerous Illustrations. Price 45/- net.

This second volume fully maintains, if it does not exceed the high position occupied by the first. Forty-nine contributors, all of them leading authorities in their respective branches, contribute to this volume. From such a list, or from the articles themselves, it would be invidious to select names or articles in any order of merit, but attention may be drawn to those dealing with fermentation glass, coal, gas, fuel, fertilisers, explosives, evaporation, disinfectants and chlorine, on the grounds of completeness, and utility.

We have again to congratulate the Editor on the efficient, and satisfactory way, in which this work is being compiled, and to point to the great advance, which can be readily observed, in this new edition, which makes this dictionary increasingly useful from a practical point of view.

"METALLURGY." By W. Borchers. Translated from German by W. T. HALL and C. R. HAYWARD. Pages 271, including Index. 218 Illustrations. JOHN WILEY & SONS, New York, 1911 Price 12/6 net.

This work presents in a satisfactory way the different processes used for extracting ores and the refining processes connected with the same. The present translation, which seems to be well done, certainly gives, as claimed, a very concise account of modern work and practice. The illustrations are very clear, and present in each case the salient features of the apparatus illustrated. The metals dealt with include gold, platinum, silver, mercury, copper, lead, tin, antimony, nickel, manganese, aluminium, etc.

The information given is compressed into the smallest possible space, and a great deal of useful detail will be found within the covers of this volume.

"HISTORICAL PAPERS ON MODERN EXPLOSIVES." By George W. MacDonald. Pages 192 + x, with Index. WHITTAKER & Co., London, 1912. Chapters XXVII. Price 7/6 net.

This work at once places in the hands of explosive chemists most of the classic researches dealing with this subject, commencing with Howard's discovery of fulminate of mercury in 1800, and Schönbein's paper on gun-cotton in 1846, following Braconnot's discovery of nitro-starch in 1833, which opened out a new era in explosives. Abel's work on the stability of gun-cotton and the action of light, heat, and alkalis is reproduced. Sobrero's discovery of nitroglycerin in 1847 is then dealt with; also Nobel's patents in connection with the manufacture of the same. The remaining chapters deal with the analysis and composition of nitroglycerin, its decomposition by caustic potash, and other chemical decompositions of the same substance.

A very complete index will be found to still further add to the value of this interesting volume, which will, with its introduction by Sir Andrew Noble, certainly be found on the bookshelf in every explosive works where the English language is understood.

Books Received.

"A SCHEME FOR THE DETECTION OF THE MORE COMMON CLASSES OF CARBON COMPOUNDS," by Frank E. Weston. Longmans, Green & Co., London, 1912. Third Edition. Pages 108. Divided into sixteen sections, with 22 Illustrations. Price 3/-.

"SOIL CONDITIONS AND PLANT GROWTH," by Edward J. Russell. Longmans, Green & Co., London, 1912. Pages 168 + vi., including Appendix, Bibliography, and Index. Chapters VII., including Diagrams. Price 5/- net.

"RESEARCHES ON CELLULOSE, 1905—1910," No. III., by C. F. Cross and E. J. Bevan. Longmans, Green & Co., London, 1912. Pages 173 + vi, including Index. Chapters V., including Bibliography. Price 7/6 net.

"FORTY-EIGHTH ANNUAL REPORT ON ALKALI, ETC., WORKS," by the Chief Inspector. Proceedings during 1911. Published by His Majesty's Stationery Office, London, 1912. Pages 146, including 4 Graphs. Price 1/8.

"LIQUEFIED PRODUCTS FROM NATURAL GAS: THEIR PROPERTIES AND USES," by Irving C. Allen and George A. Burrell. Technical Paper 10, Bureau of Mines, Washington, U.S.A. Pages 23.

"THE USE OF MICE AND BIRDS FOR DETECTING CARBON MONOXIDE AFTER MINE FIRES AND EXPLOSIONS," by George A. Burrell. Technical Paper 11, Bureau of Mines, Washington, U.S.A. Pages 15.

"METHODS OF ORGANIC ANALYSIS," by Henry C. Sherman. The Macmillan Company, New York, 1912. 2nd Edition, rewritten and enlarged. Pages 407 + vi, including Index, Chapters XVIII., with 17 Illustrations. Price 10/6 net.

"THE TESTING OF WOOD PULP." A Practical Handbook for the Pulp and Paper Trades, by R. W. Sindall and W. Bacon. Marchant Singer & Co., London, 1912. Pages 148, including Index and 3 Appendices. Sections IX, with numerous Illustrations. Price 5/- net.

"FIRST ANNUAL REPORT OF THE DIRECTOR OF THE BUREAU OF MINES TO THE SECRETARY OF THE INTERIOR FOR THE FISCAL YEAR ENDED JUNE 30TH, 1911." Bureau of Mines, Washington, U.S.A., 1912. Pages 57 + iv, including 1 Illustration.

"THE BEHAVIOUR OF NITROGLYCERIN WHEN HEATED," by Walter O. Snelling and C. G. Storm. Technical Paper 12. Bureau of Mines, Washington, U.S.A., 1912. Pages 14, including 2 Illustrations.

"GAS ANALYSIS AS AN AID IN FIGHTING MINE FIRES," by George A. Burrell and Frank M. Seibert. Technical Paper 13. Bureau of Mines, Washington, U.S.A., 1912. Pages 16, including 1 Illustration.

"PERMISSIBLE EXPLOSIVES AND PRECAUTIONS TO BE TAKEN IN THEIR USE," by Clarence Hall. Miners' Circular 6. Bureau of Mines, Washington, U.S.A., 1912. Pages 19.

"DETERIORIATION AND SPONTANEOUS HEATING OF COAL IN STORAGE," by Horace C. Porter and F. K. Ovitz. Technical Paper 16. Bureau of Mines, Washington, U.S.A., 1912. Pages 14.

"THE TECHNOLOGY OF IRON ENAMELLING AND TINNING," by Julius Grünwald. Charles Griffin & Co., Ltd., London, 1912. Pages 138 + vi, including Index. Chapters XVI. Price 6/- net.

"THE SLAGGING TYPE OF GAS PRODUCER," by Carl D. Smith. Technical Paper 20. Bureau of Mines, Washington, U.S.A., 1912. Pages 13, including 1 Plate.

"THE FACTOR OF SAFETY IN MINE ELECTRICAL INSTALLATIONS," by H. H. Clark. Technical Paper 19. Bureau of Mines, Washington, U.S.A., 1912. Pages 14.

"THE CONSTITUTENTS OF COAL SOLUBLE IN PHENOL," by J. C. W. Fraser and E. J. Hoffman. Technical Paper 5. Bureau of Mines, Washington, U.S.A., 1912. Pages 20, including 1 Plate.

"THE STATUS OF THE GAS PRODUCER IN THE UTILISATION OF FUELS," by Robert Heywood Fernald. Technical Paper 9. Bureau of Mines, Washington, U.S.A., 1912. Pages 42 + iv, including 6 Illustrations.

CHEMICAL ENGINEERING.

INTERNAL COMBUSTION PUMPS AND COMPRESSORS.

By J. G. Davis, B.Sc. (Eng.), A.C.G.I.

Considerable interest has been aroused of late by the successful application of the energy of expanding gases *directly* to the problem of raising or forcing large quantities of water or other liquids.

The remarkable fuel economy and the high efficiency of working secured, combined with a notable flexibility in meeting conditions differing widely, at once commend this system, which is due to Mr. H. A. Humphrey, M.Inst.Mech.E. A series of inventions embodying the direct displacement of liquids by gaseous fuels expanding in suitable containing vessels (as in an ordinary internal combustion engine, working not on the usual Otto cycle, however, but on a cycle approaching much more nearly the perfect heat cycle of operations described in works on Thermodynamics) has led to the construction of various types of machines working without the aid of pistons or of any moving mechanical parts, with the exception of a suitable system of valves, and means of ignition and control.

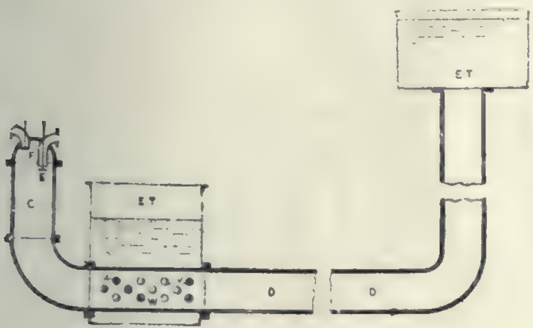


Fig. 1.—A Simple Pump.

That maximum economy of working can be attained by the principle of internal combustion has been recognised, but the coupling of pumps direct to gas or oil engines has not led to good results on the whole, and the endeavours to combine in one simple apparatus both engine and pump have not hitherto been productive of high efficiency, chiefly for the reasons that the water has been driven past non-return valves by the explosion, thereby cutting off or dissipating a large amount of the useful energy of the cycle, and, secondly, that insufficient attention has been paid in such designs to the question of compression, although the increased economy obtainable in gas engines by the use of high compression ratios was well known. Thirdly, the rapid pressure increases inevitably associated with explosions have rendered all systems necessitating the driving of liquids through valves rapidly opened a prey to mechanical difficulties and stresses due to shocks.

The Humphrey system, described broadly, employs the energy of expansion of an ignited combustible mixture to produce free reciprocation of a column of liquid in a play pipe, the whole of the functions of the cycle of operation being performed by virtue of the momentum of the moving column, which acts also as a means of transmitting the energy necessary for the working of the valve gear, and preparing completely for the next ignition.

The consideration of the simplest case of a pump worked on the above principle, viz., one suitable for direct lift without suction and running on the basis of four strokes per cycle, will provide the key to the understanding of the other types, and is best made clear by such a diagram as Fig. 1. Three main castings are essential to the pump proper: a combustion chamber C connected by a bend to the water valve chamber W fitted with valves V opening inwards, and of plain mushroom type and fitted with light springs. The discharge pipe D leads water taken in from the supply tank S T to the elevated tank E T. An inlet valve A and an exhaust valve E are fitted to the upper part of the combustion chamber and so connected by a simple interlocking gear that the opening of the one and its subsequent closing locks it in the closed position and at the same time releases the other valve. In consequence of this, the valves open in turn each time that suction occurs in the chamber C. A sparking plug projects through the top casting, and at the moment when this causes the explosion of a charge of gas and air compressed in the top of C, all valves are shut, so that the water is driven

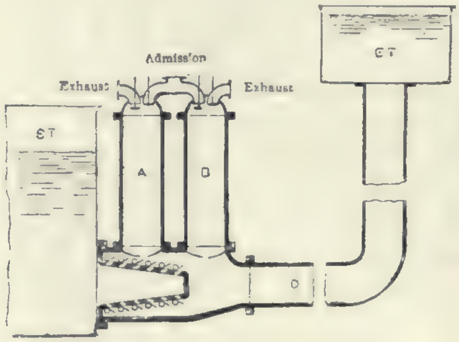


Fig. 2.—A Double-Barrelled Pump.

downwards by the increase of pressure, the whole column of water in the discharge pipe being thereby set in motion. As long as work is being done upon it the liquid continues to attain kinetic energy, so that it may attain considerable velocity by the time the expanding gases fall to atmospheric pressure. But owing to the time necessarily elapsing before the moving column can come to rest, the gaseous volume in C is caused to exceed that corresponding to atmospheric pressure, so that exhaust valve E opens, and also the water valves V, allowing water to rush in through the openings presented for flow from S T, partly to follow the column in the play or delivery pipe D, and partly to rise in chamber C in an effort to attain in C the level of the water existing in the suction tank. When the kinetic energy of the water has been expended in thus forcing liquid into the water tower, it comes to rest. But there is nothing to prevent a return flow, and the column starts to move back towards the pump, and gains velocity until it reaches the level of the exhaust valve E, which it shuts by impact, so imprisoning a certain quantity of the burnt products of the combustion in the cushion space F, the pressure of these gases being increased subsequently to the shutting of the exhaust by the on-coming column being retarded by the cushion until it is brought to rest. A rebound occurs due to the cushioned gas having a pressure in excess of that due to the static head of the water in tank E T. The column being so propelled under the cushioning action is receiving energy, however, up to the moment when the pressure in F becomes again atmospheric, but owing to its inertia it continues to move in the same direction, bringing the pressure in C and F below atmospheric, and so causing valve A to open against a light spring, drawing in a fresh charge of gas and air.

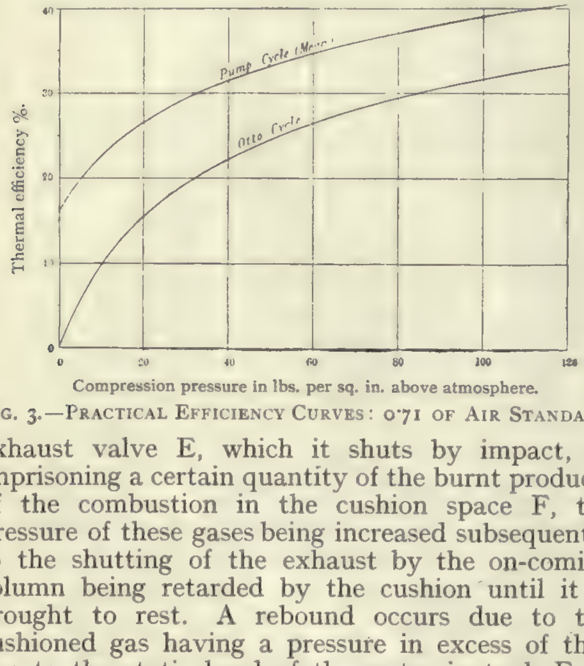


FIG. 3.—PRACTICAL EFFICIENCY CURVES: 0·71 OF AIR STANDARD.

In the absence of friction the water would fall to the level from which the last upward motion started, but actually the amount of combustible charge is just less than this movement would represent. The water column now returns under the elevated tank pressure and compresses the charge of combustible, the ignition of which starts the cycle of operations anew. The strokes are thus: a long stroke during combustion and expansion, a short stroke during suction, and a still shorter one during compression. Discharge into an air vessel or into a standpipe or tower with open top instead of into an elevated tank, as in Fig. 1, does not affect the working of the pump, and both of these alternative arrangements are useful for securing continuous flow from an outlet. The degree of compression in the simple form of pump described depends on the kinetic energy acquired by the liquid column on its return towards C, and the cushion pressure attained is determined by similar considerations, and rapidly rises with the "lift" up to or even above the explosion pressure. The ignition is timed by a small device similar somewhat to an ordinary engine indicator, closing the electric circuit to secure ignition at the point of maximum compression. It consists of an accumulator or other source of electric energy, with trembler coil and sparking plug of the usual type.

Smooth, quiet working of the pump results from the only moving parts, namely the valves, being all on their seats when explosion occurs, and opening and shutting under comparatively small pressure changes. In first starting up a pump of this type a rather larger volume of compressed air than the usual charge is passed into the combustion chamber, and by the opening of the exhaust valve by hand the air escaping produces a motion of the water column corresponding to the cushion and suction strokes, drawing in the first combustible charge. Subsequently, the pump always stops with a fresh charge of gases in C, and nothing but switching on of the ignition current is needed to start up, which is a marked advantage over the starting of large gas engines. Tests on such a pump made officially by Professor W. C. Unwin, in 1909, gave results, which in common with those obtained from much larger ones since constructed, are highly satisfactory, the thermal efficiency (on water lifted) exceeding 23%. Throughout the trials the pumps worked with varying lift without any alteration in the cushion volume or in the gas and air mixture, and without misfire or hitch of any description. Quoting figures to indicate dimensions of pumps of this type, a 24 in. diameter of play pipe with a maximum velocity of flow of 14 ft. per second, gives for a length of pipe varying from 50 to 100 ft. a number of cycles per minute, varying between 31 and 14·3, and corresponding discharges from 486 to 447 cu. ft. per minute, the efficiency reckoned as the ratio (HP developed in water pumped: Indicated HP of expanding gases) being in the respective cases 0·95 and 0·91 meaning a loss varying from 5% to 9% of the energy developed by the gases. A greater velocity than that here mentioned may often be used with advantage.

The Humphrey pump, exhibited at the Brussels Exhibition of 1910, secured the "Grand Prix" both in the class for gas-engines and in that for pumps, it delivering water at the rate of 6,000,000 gallons per day. At the Turin Exhibition of 1911, one delivering 16,000,000 gallons per day was shown in operation, and among the schemes in which the pump is being employed industrially may be mentioned the plant put down for the Metropolitan

Water Board at Chingford, where four Humphrey pumps each of capacity 40,000,000 and one of capacity 20,000,000 gallons, deal with 180 million gallons of water per 24 hours, the lift being 25 to 30 ft. From the figures it appears that in dealing with large discharges the saving in initial outlay effected by this type of plant is very considerable, and it must be admitted that this is not at the expense of compactness.

An important modification of the single-barrel four-cycle pump hitherto dealt with is found in the two-cycle double-barrelled type illustrated in Fig. 2, which involves only two strokes of the water column, and in which explosion occurs alternately in the combustion chambers A and B. It depends for its successful operation upon the fact that towards the end of the long expansion stroke the burnt gases have been so well cooled that they will not ignite an incoming combustible charge. Assuming such a charge to be compressed in A and chamber B to be full of liquid, explosion and expansion in A propel the water column outwards, the exhaust of A opening when atmospheric pressure has been reached. Water, therefore, flows in and follows the column, also rising in A and expelling burnt products, the level falling in B at the same time, since there is insufficient pressure to maintain the water in that chamber, and a fresh charge of gases is drawn into B. The outgoing column does not come to rest until after all this has happened, and in returning it expels through the still open exhaust valve the remaining burnt products in A, and compresses the new charge in B, since the valve which admitted it is now locked. By the rising of the returning column the exhaust in A is shut, and ignition in B starts a fresh cycle with the functions of A and B reversed. Admission here is dependent only on the fall of water under gravity, and not on cushioning, higher compression and explosion pressures are obtainable for a given lift, the cycles are more frequent, and the output for a given weight of pump and play pipe is greater. There is also a type of pump suitable for suction lift, with several modifications for various conditions, and special arrangements for efficient scavenging can be introduced. Any single or double barrel Humphrey pump is readily converted into a high lift pump by the addition of a so-called "intensifier," which is an air vessel suitably fitted with valves. A further very promising modification employs the water column oscillating in the play pipe as a water piston, the water caused to rise and fall in an air vessel carrying valves for the inlet and outlet of air, the combination constituting an efficient and useful type of air compressor, the flexibility of which is as marked as that of the pump. These are constructed by the Pump and Power Company, Ltd., in several patterns, and have, it is believed, met with considerable success.

The practical efficiency curves of Fig. 3 give a sufficiently near indication of the comparative values of the Humphrey and Otto cycles, based on the assumption of constant specific heat; but it may be pointed out that when corrections for varying specific heats have been made the pump cycle shows an absolute thermal efficiency of 52·5 %, with a compression pressure of 11 atmospheres, against 40 % on the Otto cycle.

Seeing that an actual thermal efficiency of over 23 % has been obtained on a four-cycle Humphrey pump with a 50 lbs. per square inch compression, this test corresponding to 0·95 lb of anthracite coal per water horse-power (on a lift of 35 ft. only), it seems evident that efficiency can be here much improved by the use of high compression, as in gas-engines, with the best results of which this new system is able to compare favourably. In addition to the installation costs saved in many cases, the elimination of large moving and sliding parts and the necessity of lubricating them causes a distinct saving in running costs, apart from the welcome, but too often, overlooked quality of simplicity of construction and operation.

INSTITUTE OF METALS.

Annual Autumn Meeting.

Arrangements for this meeting to be held on September 25th and 26th are in the hands of an Executive Committee composed of the London Members of Council of the Institute.

The Meeting for which ten papers have been presented, will open at 10.30 a.m., on Wednesday, September 25th, and will be held at the Institution of Electrical Engineers, Victoria Embankment, W.C. During the morning a series of papers will be read and discussed, Professor W. Gowland, F.R.S., Assoc. R.S.M., President, being in the Chair. In the afternoon Members will proceed either to the works of Messrs. Fraser & Chalmers, Ltd., Erith, or to the National Physical Laboratory, both of which will be open to their inspection.

In the evening there will be a Reception by the President, of the Members and their Ladies, which will take place at the Royal United Service Institution, Whitehall, S.W.

On Thursday, September 26th, papers will be read and discussed at the morning session of the Institute at the Institute of Electrical Engineers, and in the afternoon alternative excursions will take place, one being to Woolwich Arsenal, by special steamer from the Embankment, and the other being a visit to the Brooklands Motor Race Course and Aviation Ground, special motors being provided for the conveyance of the party. Weather permitting, Aeroplane Competitions will take place for the Institute of Metals Aviation Prize.

Further particulars may be obtained from the Secretary, Mr. G. Shaw Scott, M.Sc., Caxton House, Westminster, S.W.

Alkali, &c., Works Forty-Eighth Annual Report.—Interesting particulars are contained in this report, concerning the number of registered works in the United Kingdom, which show a net increase of 29, making 1,463 in all. The escape of acid from chimneys shows a decline on the average. An extended adaption of mechanical appliances is recorded, including two new mechanical furnaces for cuprous pyrites. The cement industry has shown great activity.

PERSONAL AND OTHER NOTES.

An Examination in Biological Chemistry, Bacteriology, Fermentation, and Enzyme Action, will be held at the Laboratories of the Institute of Chemistry, commencing on Monday, the 14th day of October, 1912. The Examination extends over five days, and may be theoretical and practical, and both written and oral. The syllabus includes Biological Chemistry, Bacteriology, Fermentation, and Enzyme Action, with special reference to the Chemistry and Bacteriology of Food-Stuffs, Water Supply and Sewage Disposal, and the application of Biological Chemistry to Industries and Manufactures. The Examination will be open to Fellows and Associates, to Candidates whose applications for admission to the Final Examination have been accepted by the Council, and to Candidates who have passed the Intermediate Examination of the Institute, provided they produce evidence satisfactory to the Council of having taken a course in Elementary Biology.

The Council of the Institute of Chemistry are also prepared to arrange examinations in Chemical Technology to be held in October, 1912. The Examinations will be open only to Fellows, and to those Associates who have been registered as such for at least one year, who produce evidence of practical technological training. Applications not later than the 10th of September, 1912.

Mr. John Hall, of Silverlea, St. Leonards, Sussex, brother of the late Sir Samuel Hall, K.C., died on June 9th, leaving £40,000 to the Victoria University, Manchester, in memory of his brother, as to £20,000 for a Samuel Hall Professorship in Chemistry, £15,000 for a Samuel Hall Professorship in Philosophy, £2,500 for not more than two Samuel Hall Scholarships in Philosophy, and £2,500 for not less than two Samuel Hall Scholarships in Chemistry. The ultimate residue he left for John Hall Scholarships.

Dr. Arthur E. Hill, of New York University, has been appointed Professor of Chemistry and Director of the Laboratory to succeed Professor Lamb.

Professor Charles Baskerville has been awarded the Edward Longstreth Medal of Merit by the Franklin Institute for his investigations on the Chemistry of Anæsthetics.

Professor Smithells, F.R.S., of Leeds University, has been appointed by the Harrogate Corporation, to conduct a series of investigations on the waters of that district. Sir William Ramsay has entered into an engagement to act as scientific adviser to the Development Syndicate which proposes to lease the baths from the Bath Corporation.

The establishment of a South African Teaching University at Groote Schuur, for which the sum of £500,000 was left by Sir Alfred Beit and Sir Julius Wernher, has been the subject of important conferences in London during the past month.

It is announced in *Nature* that the following appointments have been made at the London (Royal Free Hospital) School of Medicine for Women. Mr. J. A. Gardner to be lecturer in organic chemistry and head of the Department of Chemistry, in succession to Miss C. Evans; Miss Widdows to be lecturer in organic chemistry.

Mr. J. Golding has been appointed research chemist in dairying at University College, Reading.

COMMERCIAL AND GENERAL NOTES.

Artificial Silk for Incandescent Mantles.

A comparatively new branch of the artificial silk industry is the manufacture of incandescent mantles. The superiority of these to mantles of ramie or China grass has been proved by many practical experiments. The writer of an article in a recent issue of the *Journal für Gasbeleuchtung* prophesied a brilliant future for artificial silk mantles which are proving particularly useful for lighting streets with a great amount of heavy traffic, as they are not easily affected by vibration and shocks. The same quality renders them valuable for railway lighting. In order to test their resistance to shocks a special machine has been constructed. Experiments made on this machine have proved that ramie mantles which had not been burned before would stand 500 to 1,000 shocks on the machine, and after 10 hours burning only about 100 shocks. On the other hand, good mantles of artificial silk would resist some 6,000 shocks before burning, and on the average another 6,000 shocks after burning for a period of 500 hours. Even after burning they are strong enough to stand certain tests with a weighting apparatus. A mantle of this kind, though only weighing 1 gm., was able to support a weight of about 20 gms. In consequence of these favourable results one may find the use of artificial silk mantles extending at a rapid rate.

Utilisation of Atmospheric Nitrogen.

The importance of nitrogenous compounds to the industrial and agricultural interests of the country has prompted the United States Bureau of Manufacturers of Washington to issue a monograph on the subject of utilising atmospheric nitrogen in the production of such compounds.

The nitrogen problem, one of the most pressing of the twentieth century, is unique from the fact that the material is unlimited. The atmospheric nitrogen above one square mile of land, amounting to about 22,000,000 tons is equivalent to what the world would require in the next fifty years at the present rate of consumption. The problem is to utilise this nitrogen economically.

Remarkable results have been obtained in Norway by means of electric furnaces in which atmospheric nitrogen is oxidised to the form of nitric oxide which is used in making calcium nitrate, or Norway saltpetre. This Norwegian product is already a competitor of Chile saltpetre. The success of the process depends upon a very cheap supply of electricity.

Cyanamide, another nitrogenous fertiliser of growing importance, is being successfully manufactured in America. The monograph describes in detail the results obtained by the leading European chemists in their efforts to increase the supply of nitrogenous compounds, and the commercial as well as the technical aspects of the new industry are dealt with at length.

In conclusion, the author states that the achievements of applied chemistry make it possible for American industry and agriculture to face with confidence the successful utilisation of atmospheric nitrogen.

White Lead Production.

The Western Lead Paint Company, a large paint concern of Spokane, Wash., are working according to a new process which promises to be very profitable, and to represent a development of great interest in the metallurgical-chemical industry. There are now on hand several hundred pounds of white lead, chrome lead and prussian blue, taken directly from the mineral without the intervention of the refinery or smelter. The process, which has now been thoroughly tested, is said to be quite revolutionary in the metallurgical line. A solution of nitric acid and other chemicals is poured over the ore, which has first been ground to a 50-mesh size, and left to stand about 6 hours. Then the solution is poured off, run into large vats, and there the lead is precipitated out by the use of soda and other reagents. It is then a pure white lead, or chrome lead. The silver is precipitated out as a chloride, and the iron as prussian blue, all of which are marketable commodities. The nitric acid and other chemicals used are returned from the solution by evaporation after the metals have been procured in the form of saltpetre. This is turned back into acid. The white and chrome lead is compressed and dried after settling down in the vats.

Sharpening Files.

A German firm in Westphalia has brought out a chemical preparation for the purpose of sharpening files. At a recent demonstration at Solingen (the so-called German Sheffield), a great number of workmen had been invited to bring files which needed sharpening in order to test the new process. A pail was filled with boiling water, to which a bottle of the new preparation was added. This served to clean the files and remove any impurities such as oil, dirt, filedust, etc. After cleaning the files to be treated they were put in a water-tight and acid-proof compartment, the two ends of each file resting on a small block of wood, and immersed in a liquid consisting of pure cold water and two chemical preparations. The strength of the mixture was regulated according to the cut of the file. In a short time the sharpening process began, which could be detected by the darkening and heating of the fluid. The files remained about 45 minutes in the bath and were then washed in clear, cold water. In order to see whether they were sharpened enough they were taken out from time to time and examined. Dried in sawdust and brushed over they were almost like new files and as sharp as the workmen could wish for. The demonstration did not show how long they remained sharp, but the inventor of the preparation claims that rough files may be treated five or six times in this way. The chemical sharpening is said to be cheap and convenient.

Tunny Oil from Sicily.

Tunny oil, which is used in the manufacture of chemical products, is a by-product of the canning industry in Sicily. The tunny fisheries, some forty in number, are located along the northern coast of the island from Trapani and Messina. The fish are caught in May and June, and the quantity canned annually varies from 15,000 to 40,000 boxes of 80 kilogrammes each. The tins used hold from one-fourth of a kilogramme to 20 kilogrammes. From the refuse of the canneries about 10,000 kilogrammes of tunny oil are extracted, the average price for the oil being about £2 per 100 kilogrammes. To extract the oil, the refuse is boiled from 24 to 48 hours, and then passed through metal presses similar to those used in olive oil establishments.

Another New Rubber Substitute.

Synthetic rubber being very much "in the air" just now, it is interesting to learn that a new Dutch company has recently been formed for the purpose of utilising sea-fish for the manufacture of rubber substitutes. A large factory is in the course of erection at Ymuiden which will be in charge of an Austrian expert, Dr. Adler. The process to be used is the invention of Dr. Van der Heyden, formerly teacher at a university in Japan. It has been patented in Austria and Belgium, and will shortly be patented in all other countries. The details of the process are naturally not disclosed. It consists roughly in mixing fish with 15 or 16% of natural rubber, producing a material which is as elastic and strong as real rubber but is considerably cheaper. In fact, it costs about eight times less. Another advantage of the new product is its greater resistance to heat, benzine, etc.; moreover, its vulcanisation is easier and quicker. The inventor also claims to produce albumin as a by-product from the fish-flesh. The new company intends to take up the manufacture of fish fertilisers as well.

Financial Results of Continental Artificial Silk Firms.

The report just issued by the Soie Artificielle, the French company working the cupro-ammonium process of the Vereinigte Glanzstoff-Fabriken, Elberfeld, discloses a net profit of 574,365 francs, against 416,634 francs last year, allowing a dividend to be paid at the rate of 22½% a year, against 16½% last year. The agreement with the Soie Artificielle d'Yzieux and the various French companies working the viscose artificial silk process is giving satisfactory results. The gross profits of the Yzieux Company have advanced from 511,834 francs in 1910 to 712,341 francs in 1911, and the net profits amounted last year to 423,740 francs.

The competitive ability of the gun-cotton artificial silk process as against the cupra-ammonium and viscose processes does not appear to improve. The Plauen Artificial Silk Works at Plauen, a company formed in 1910, has decided to close down the works temporarily, the present high alcohol prices in Germany making profitable working impossible.

The Berlin Radium Institute.

The opening of the new Radium Institute in Berlin was recently celebrated in a manner befitting such an interesting event. The Institute receives several valuable subventions which will enable it to do most useful work. From the Kaiser-Wilhelm-Gesellschaft it receives a yearly grant of 10,000 marks (for three years), and from the Radiogen-Gesellschaft of Charlottenburg and the Allgemeine Radium A.-G. in Amsterdam each a contribution of 5,000 marks per annum, in addition to all the necessary material and apparatus. These grants are made quite unconditionally. The Institute proposes to undertake valuable theoretical biological research work under the superintendence of Hartwig. Privy Councillor Markwald superintends the physical department, and Dr. Neumann the chemical one. The programme of the Institute includes also chirurgical and dermatological research work. Students who do not belong to the Institute will be allowed the use of the laboratories, etc. The Institute is at present in the possession of radium preparations and mesothorium to the value of some 180,000 marks. Madame Curie, of Paris, has presented 2·80 milligrammes of radium salts to the Institute.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

15850/11. A. MCKECHNIE and F. G. BEASLEY, Birmingham. **Treating Nickel Copper Mattes.** 8 July, 1911.

A process or method of treating raw or partially roasted high grade or concentrated copper nickel mattes for the purpose of effecting, at one operation, the extraction of the whole of the nickel content as soluble salt and the purification of the nickel solution from dissolved copper consists, according to this invention, in digesting the matte with sulphuric acid (or other similarly acting acid) in a closed vessel and under conditions of high temperature and pressure, whereby, primarily, the acid is made to act rapidly and directly upon the nickel sulphide and produce a sulphate, chloride or other nickel solution, whilst, as a secondary result, the sulphuretted hydrogen formed by the primary reaction is effectively utilised to simultaneously eliminate dissolved copper salts by precipitating the same as sulphide. (1 claim.)

17157/11. F. GIROD, Grevenbrück. **Sulphuric Acid.** Dated, under International Convention, as 13 August, 1910.

The process of manufacturing sulphuric acid, free from arsenic and iron, by the chamber method consists, according to this invention, in submitting the burner or kiln gases, containing sulphur dioxide, to mechanical purification, then passing said gases immediately and while still comparatively hot in contact with nitrous vitriol to which may have been added nitric acid, thereby denitrating the said nitrous vitriol and oxidising any arsenious acid present in the said gases, then completing the denitration of the nitrous vitriol and passing the gases through washing or rinsing towers, and then submitting them to the lead chamber action (5 claims, 1 Fig.).

17424/11. G. W. JOHNSON, London. **Acetic Acid.** 31 July, 1911.

According to this invention, it has been found possible to very rapidly and easily oxidise aldehyde into acetic acid by means of air or oxygen, if, from the commencement of the operation, glacial acetic acid, its chlorine derivatives, such as mono-, di-, or tri-chloracetic acid, acetic anhydride, or homologues of these compounds, be added to the aldehyde. (2 claims.)

18659/11. L. D. M. Y. ALDAMA, Staines. **Distillation of Carbonaceous Materials.** 18 August, 1911.

According to this invention, the volatile matters in carbonaceous materials, solid at ordinary temperatures, are extracted by diffusion or percolation through the heated material of a gaseous medium adapted to carry away the volatile matter, the medium being heated prior to its diffusion through the material to the same or substantially the same temperature as the material itself at the point of contact of gas and material, so that both are subjected thereafter to the same conditions within the retort. (2 claims.)

20611/11. H. IMMENDORFF and H. KAPPEN, Jena, Germany. **Urea.** Dated, under International Convention, as 19 September, 1910.

In examining the catalytic action of a great number of substances with a view of ascertaining their suitability for use in the manufacture of urea from cyanamide, the applicants have found that the hydrates of manganese peroxide are particularly efficient and suitable as catalysers; inasmuch as by their use the time of transforming the cyanamide into urea is considerably shorter than with other catalysers; their catalytic efficiency remaining moreover constant during a very long time. (2 claims.)

20706/11. J. H. WEBSTER, Carrickfergus, and International Salt, Ltd., London. **Manufacture of Salt.** 19 September, 1911.

According to this invention, discoloured rock salt, or salt made by artificial or natural evaporation, or otherwise, is melted by heat in a furnace or chamber and as it is melted it flows into a secondary chamber or furnace wherein it is continuously agitated and operated upon by air, by forcing it through, or by mechanical agitating means, or both, and from this chamber, wherein it is maintained in a full fluid state by heat, it is arranged to flow continuously into another chamber or vessel, also heated, and flow through it quietly, and to continuously and quietly discharge or flow from it. In this passage through the latter chamber or vessel, the foreign solid and discolouring matters contained in it, fall to the bottom and are retained while the purified white salt passes off and is collected. (2 claims.)

21519/11. J. Y. JOHNSON, London. **Isoprene.** 29 September, 1911.

The manufacture of isoprene and of homologues thereof is effected, in accordance with this invention, by heating in the vaporised condition, whilst in a state of dilution, and in the practical absence of other organic hydrocarbons, the dipolymerised, or more highly polymerised, products of isoprene, or of homologues thereof, (with the exception of dipentene) which products result as by-products in the manufacture of caoutchouc or caoutchouc-like bodies, from isoprene or the like. (2 claims.)

23038/11. J. GAYLEY, New York. **Sintering Fine Ores.** Dated, under International Convention, as 8 June, 1911.

Brittle and porous or cellular pieces of ore material suitable for subsequent smelting treatment are produced from finely-divided ore deficient in combustible material by intimately mixing with the finely-divided ore carbonaceous substance, disposing the mixture in a layer on a moving bed or conveyor, and sintering it under a down-draught action during its travel, which intensifies the combustion in the fore part of the operation, and towards the end, after the complete combustion of the carbonaceous material, acts to cool the sintered mass. (1 claim.)

6364/12. F. ROGERS, Sheffield. **Pyrometers.** 14 March, 1912.

The invention consists broadly in a pyrometer having a temperature-measuring device, for example, a thermocouple, separated from the source of heat by a suitable protecting sheath to which there is supplied a current of cooling fluid adapted to reduce the temperature of the measuring device and of the portion of the sheath in the furnace. (3 claims, 3 Figs.)

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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INSTITUTE OF CHEMISTRY BUILDING FUND.

UNTIL the founding of the Institute of Chemistry in 1877, no serious attempt had been made to organise the profession of Chemistry and no body existed for the maintenance of the welfare of the profession. There was no standard of qualification, while genuine practitioners found themselves frequently interfered with by those whose methods both in securing and in conducting their practices would not be tolerated at the present day. By devising and constantly revising the regulations for the training of those who wished to adopt this profession, and by steadily improving its system of conducting examinations, the Institute has created a truly professional body, to the members of which it is claimed that the public may reasonably look for guidance in matters chemical with a sense of security both as to their competency and their integrity.

The Institute, for thirty-five years, has been entirely self-supporting. Its income, being derived from subscriptions of members (numbering nearly 1,400) and fees of candidates, is barely sufficient, under most economical management, for its current needs. As the membership has increased, the sphere of usefulness and, consequently, the expenditure of the Institute have been constantly extended. Though, as its title indicates, its main sphere of operations is Great Britain and Ireland, the Institute is actually an imperial organisation, and its influence and work have been extended to India and the oversea British Dominions, where examinations are held for local candidates.

The Council of the Institute are now seeking to obtain more suitable and permanent headquarters, and the approaching expiry—at Michaelmas, 1914—of the lease of the present premises, 30, Bloomsbury Square, provides a suitable opportunity to accomplish this end. We understand that there is no possibility of effecting a renewal of the present lease, as not only has the site value greatly increased, but the site is included in an improvements scheme of the London County Council, viz., the widening of Southampton Row. The premises, moreover, have become inadequate for the increasing activities of the Institute; and at the present time it is found necessary to obtain the use of additional laboratories in other institutions for examinations in certain branches of work.

The new building will include more commodious Meeting Rooms, Library, Laboratories, and Examination Rooms than it at present possesses and increased office accommodation. The Council estimate that a ground area of about 4,000 square feet will be necessary, and they hope to select a suitable site, freehold or on a 99 years' lease, within the next few months.

It is estimated that the buildings and fittings, without unnecessary extravagance or ostentation, will cost about £15,000, and an appeal has been made to Fellows and Associates of the Institute which has already resulted in the receipt of contributions and promises amounting, with dividends and interest, to over £10,000. Chemists, as a body, are neither numerous nor wealthy, and indeed it shows a laudable effort on the part of some 1,400 Fellows and Associates who have subscribed no less than £8,800, the remaining £1,200 having been contributed by several of the great City Companies and a number of firms and individuals not directly connected with the Institute.

The work of the Institute deserves the widest support, and therefore the list of contributors to the Buildings Fund is now being extended to the public. The Council look to the generosity of all who are interested in Chemical Science and who sympathise with scientific endeavour, to assist them in this undertaking. They appeal especially to those who employ chemists and realise the importance of the science of chemistry to the progress of industry, and those engaged in scientific industry who have benefited by the steady raising of the standard of the professional competence of chemists may like to show their appreciation of the usefulness of the Institute by giving their support to this Fund. We may mention that contributions can be forwarded to the President at 30, Bloomsbury Square, London, W.C.

Origin of Life.

A presidential address delivered before the British Association often supplies occasion for general speculation. The general public is let into the secrets of some section of scientific investigation, or the aspirations of its followers. It is already history that the last address by Professor Schäfer was given up to a consideration of the possible synthesis of a certain phase of life.

The address was interesting in its attempt to break down some of the barriers between certain sections of science, and a consideration of the question in its broader aspect. Also for the fact that the next step to be taken was allocated to the chemist, who is apparently expected to produce synthetically certain substances which will then naturally exhibit (in the opinion of this authority) the properties of living matter.

Whether this step will ever be taken in the laboratory is open to question. Just as a certain period of time is required to effect crystallisation, so the time factor in the case in question may be beyond the limit set to personal investigation. The passing through the "borderland" to organised Life (*Protista*) from certain conditions which can be brought about by such physical means as surface energy may not even be possible. There may be intermediate steps. Life may only be the final expression of a long series of phenomena.

On the other hand, there may be no real connection between the physical forces mentioned and those of Life itself.

The interdependence of different sectional organs, and even the possibility of their being replaced by those of a similar one, taken from a subject in which animation has been suspended, is one which introduces new vistas which it is hardly possible to appreciate. Such phenomena as those set out in the address are undoubtedly of deep significance.

> "Even so complex a process as the division of a cell-nucleus by *karyokinesis* as a preliminary to the multiplication of the cell by division—a phenomenon which would *primâ facie* have seemed and has been commonly regarded as a distinctive manifestation of the life of the cell—can be imitated with solutions of a simple inorganic salt, such as chloride of sodium, containing a suspension of carbon particles; which arrange and re-arrange themselves under the influence of the movements of the electrolytes in a manner indistinguishable from that adopted by the particles of chromatin in a dividing nucleus. And in the process of sexual production the researches of J. Loeb and others upon the ova of the sea-urchin have proved that we can no longer consider such an apparently vital phenomenon as the fertilisation of the egg as being the result of living material brought to it by the spermatozoon, since it is possible to start the process of division of the ovum and the resulting formation of cells, and ultimately of all the tissues and organs—in short, to bring about the developments of the whole body—if a simple chemical reagent is substituted for the male element in the process of fertilisation. Indeed, even a mechanical or electrical stimulus may suffice to start development."

The relationship between what we term Life and Death has recently been regarded in a new sense. The physical Death of a highly specialised organism is not apparently a simple phenomenon, or necessarily a rapid sequence of events. Special organs may live for considerable periods after the outward phenomenon of Death is established by the accepted tests. Actual growth and reproduction, Professor Schäfer points out, are not, in their widest sense, confined to Life. It seems difficult to take any individual factor in Life as defined by Professor Schäfer and not find it seemingly represented in some physical aspect of matter.

The difficulty in distinguishing certain phenomena which are observed in "living" and the so-called "inanimate" matter, where seemingly similar movements can be produced "to order," is certainly becoming increasingly difficult. Just as no division is apparent between the simplest and the most complex forms of life (which are actually built up of the simplest) it may be increasingly difficult to formulate differences between "living" and "inanimate" matter, in terms which are at present recognised.

Vitalism.

The address was chiefly remarkable in its attack on Vitalism.

> "Vitalism as a working hypothesis has not only had its foundations undermined, but most of the superstructure has toppled over, and if any difficulties of explanation still persist, we are justified in assuming that the cause is to be found in our imperfect knowledge on the constitution and working of living material. At the best, vitalism explains nothing, and the term 'vital force' is an expression of ignorance which can bring us no further along the path of knowledge. Nor is the problem in any way advanced by substituting for the term 'vitalism' 'neo-vitalism' and for 'vital force' 'biotic energy.'"

It may be argued that the original experiments, which were said to prohibit the possibility of spontaneous generation, were on a scale which did not cover the whole field. They actually dealt with the spontaneous production and action of Life of a highly organised and complex nature.

Whether it will ever be possible to produce synthetically certain compounds which will exhibit characteristics of Life is very much a question of the future. The search will yield secondary results which cannot fail to be of the highest importance to the human race; and it will not be readily relinquished, for it has a fascination which is all its own. The chemist is called upon by Professor Schäfer to cut the next notch in the path of progress. No mathematical formula will suffice. The result must be equally obvious to the chemist and physicist. But, even if the pieces of the puzzle are assembled, and fitted together, the Vitalist will apparently still be able to claim that the operation is the equivalent of the assembly of the parts of a machine in their proper order, and that the origin of Life and its nature still remains "lost in a Golden Mist."

ISOPICRAMIC ACID AND ITS USE AS AN INDICATOR.

BY PROFESSOR RAPHAEL MELDOLA, D.SC., LL.D., F.R.S., ARTHUR JAMES HALE, B.SC., AND HUGH VERNON THOMPSON, B.A.

IN view of the scientific interest and the practical value attaching to those substances which, under the influence of acids or alkalis, are sufficiently sensitive to colour changes to act as indicators, any addition to our available resources in the way of compounds suitable for use in alkalimetry and acidimitry is worthy of being brought under the notice of chemists. Such a compound is 2 : 6-dinitro-4-aminophenol or isopicramic acid, which one of the authors of the present paper has had occasion to prepare in considerable quantity in connection with other researches which have been carried out in the laboratory of the Finsbury Technical College. In the course of experiments with this compound it was noticed that while the free acid and its acid salts were very slightly coloured in solution, the salts formed with alkalis were of a deep purple colour, the sensitiveness being so marked as to suggest the use of the substance as an indicator. Quantitative experiments to test the efficiency of the compound were accordingly undertaken with the results submitted below, the first series having been made by one of the authors (A. J. H.) at Finsbury, and the second series by another of the authors (H. V. T.) in the University Chemical Laboratory at Cambridge at the instigation of Professor W. J. Pope.

Preparation of Isopicramic Acid.

In the event of isopicramic acid becoming a recognised indicator it may be of use to make known a method for preparing this compound which has invariably given good results in the way of yield and purity, and which can be depended upon for any scale of working :—

Para-aminophenol is dissolved in about twenty times its weight of glacial acetic acid at the boiling temperature and the calculated quantity (one molecular proportion) of benzoyl chloride mixed with twice its volume of the same solvent added to the solution. The latter is kept gently boiling as long as hydrogen chloride is evolved, and then poured into cold water so as to precipitate the product. The precipitate is collected, washed with water, dissolved in dilute sodium hydroxide solution, and filtered to remove a small quantity of dibenzoyl derivative which is invariably formed. On acidifying the alkaline filtrate monobenzoyl-para-aminophenol is precipitated, and this compound, after being collected, washed and dried, is ready for nitration.

The dry monobenzoyl derivative is suspended in a considerable volume of glacial acetic acid, and the beaker containing the mixture cooled in melting ice. A mixture of fuming nitric acid (1·5 sp. gr.) with an equal volume of glacial acetic acid is then gradually stirred into the contents of the beaker. The addition of the nitric acid at first causes the suspended benzoyl derivative to dissolve up, but in a short time the dinitro derivative begins to form and the contents of the beaker solidify to a crystalline pulp. At this stage the addition of nitric acid is arrested, as too great an excess of the acid exerts a destructive influence, and the whole batch may be lost unless the nitration is stopped. The crystalline pulp is stirred into iced water, collected on a filter, and washed free from acid. The dinitro-benzoyl-p-aminophenol forms an ammonium salt which crystallises in deep orange-coloured needles, and which is but very sparingly soluble in cold water. In order to purify the crude dinitro compound it is therefore dissolved in boiling dilute ammonia and the solution allowed to cool; the crystalline ammonium salt is collected, washed with a little cold water, and decomposed by hydrochloric acid. The free dinitro derivative, after being washed and dried, is then ready for hydrolysis.

In order to remove the benzoyl group the dry dinitro compound is put into a glass beaker and well covered with strong sulphuric acid. A little water is then cautiously stirred in and the hot solution further heated over a Bunsen burner with constant stirring till the hydrolysis is complete. This point is best ascertained by testing a drop of the solution from time to time on a watch-glass. Since isopicramic acid is also a basic substance the drop withdrawn for the test gives no precipitate on dilution with water when the hydrolysis is complete, as the sulphate of the base remains in solution. The hydrolysis takes about 15 minutes for completion, and the acid solution must be heated till it shows slight indications of fuming owing to the volatilisation of benzoic acid. The heating is discontinued as soon as the test indicates complete hydrolysis, and the contents of the beaker, when cold, are poured into a small volume of water and the hot solution resulting from the mixture of the sulphuric acid and water allowed to stand till cold, when the greater part of the benzoic acid separates and can be removed by filtration. The acid filtrate on neutralisation with ammonia gives the isopicramic acid. The latter separates in ochreous scales, which are collected and washed and purified by dissolving in cold hydrochloric acid, filtering, and reprecipitating with ammonia. The compound when pure should dissolve in hydrochloric acid without residue. The process described, when successfully carried out, furnishes a product which is practically pure after one hydrochloric acid treatment, the last traces of benzoic acid being removed in the mother liquor.

* *

A very dilute alcoholic solution was used for titrating the alkalis named in the table with decinormal sulphuric acid solution. The results as compared with methyl orange and phenolphthalein are given below :—

Alkali.	Methyl Orange.	Phenolphthalein.	Isopicramic Acid.
Potassium Hydroxide ..	8·35 c.c.	8·30	8·35
Sodium Carbonate ..	4·90 ,,	Valueless.	4·80
Barium Hydroxide ..	14·50 ,,	14·40	14·50
Ammonia	13·15 ,,	Valueless.	13·10

The colour in dilute alkaline solution is pink, becoming sharply pale yellow on neutralisation. When solutions of oxalic and acetic acids were titrated with potassium hydroxide the end point with isopicramic acid as an indicator was indefinite and unsatisfactory.

For the next set of experiments a solution of the sodium salt was prepared by shaking up isopicramic acid in a large volume of water with a few drops of sodium hydroxide solution, taking care that an excess of undissolved acid was present. The purple solution of the sodium salt was decanted from the undissolved acid and used in the following titrations with alkalis and decinormal sulphuric acid :—

Alkali.	Methyl Orange.	Phenolphthalein.	Isopicramic Acid.
Potassium Hydroxide ..	30·7 c.c.	30 c.c. (valueless).	30·6 c.c.
Barium Hydroxide ..	14·6 ,,	—	14·6 ,,
Sodium Carbonate ..	10·7 ,,	Valueless.	10·3 ,,

Second Series of Experiments.

A solution of isopicramic acid in alcohol corresponding to a concentration of 2 gms. per litre was used. The titrations with decinormal hydrochloric acid and the alkalis named gave the following results :—

Alkali.	Methyl Orange.	Phenolphthalein.	Litmus.	Isopicramic Acid.
Sodium Hydroxide ..	10·0 c.c.	9·6 c.c.	9·9 c.c.	9·9 c.c.
Sodium Carbonate ..	10·2 ,,	Valueless.	Valueless.	9·9 ,,
Ammonia ..	8·2 ,,	,,	8 c.c.	8·0 ,,

With decinormal oxalic acid the following results were obtained :—

Alkali.	Methyl Orange.	Phenolphthalein.	Litmus.	Isopicramic Acid.
Ammonia ..	No end point.	Valueless.	7·8 c.c.	8·7 c.c.
Sodium Hydroxide	No end point.	9·5 c.c.	9·8 ,,	10·5* ,,

* End point not well defined.

With decinormal acetic acid the following result was obtained :—

Alkali.	Methyl Orange.	Phenolphthalein.	Litmus.	Isopicramic Acid.
Sodium Hydroxide	Valueless.	9·4 c.c.	9·6 c.c.	No end point.

In these experiments it was found that only 2–3 drops of the isopicramic acid solution were required to give the necessary indication. In every case 10 c.c. of the alkali solution were taken and diluted with 50 c.c. of distilled water. The readings given in the above tables represent in most cases the mean results of three observations. It will be seen from these results that with the single exception of phenolphthalein as indicator with sodium hydroxide and hydrochloric acid the apparent amount of acid required for the neutralisation of 10 c.c. of alkali is greater the more unsuitable the indicator for the particular titration. Thus in the oxalic acid and sodium hydroxide titrations neutrality is indicated by litmus with 9·8 c.c. of acid, while with phenolphthalein 9·5 c.c. were required. It is generally known that for weak acids litmus is inferior to phenolphthalein as an indicator. Comparing from this point of view isopicramic acid with methyl orange in the titration of hydrochloric acid and sodium carbonate, it will be seen that with the former 9·9 c.c. of acid were required and with the latter 10·2 c.c. of acid to neutralise 10 c.c. of alkali. This observation appeared to suggest that for carbonates isopicramic acid is a more sensitive indicator than methyl orange, and in order to test this point the following more detailed comparison was made :—

1·3255 gms. of pure sodium carbonate were dissolved in 250 c.c. of boiled distilled water. 25 c.c. of the hydrochloric acid solution gave (i.) 0·3640 gm. AgCl, and (ii.) 0·3632 AgCl, the strength of the acid thus being 0·00370 gm. HCl per c.c. With 10 c.c. of this acid the following results were obtained when neutralisation was reached with the above sodium carbonate solution in the presence respectively of methyl orange (I.) and isopicramic acid (II.) :—

	I.	II.
i.	9·98 c.c.	10·15
ii.	9·98 ,,	10·15
iii.	10·00 ,,	10·15

From the known strength of the solutions it can be calculated that 10 c.c. of the acid require for neutralisation 10·14 c.c. of the sodium carbonate solution.

From the general results of all the experiments it will be seen that isopicramic acid as an indicator, although useless for weak acids, is (1) possibly slightly superior to methyl orange for the titration of alkalis, (2) of equal sensitiveness to litmus for alkalis, and (3) superior to methyl orange for the titration of carbonates.

In placing this new indicator at the disposal of chemists we may add that among its advantages is that it is a perfectly definite compound capable of being obtained in a state of purity, whereas litmus is an indefinite substance and phenolphthalein, as prepared technically for such purposes, far from being a homogeneous compound. Methyl orange can, of course, if required, be obtained as a pure substance. It does not come within our province in this paper to discuss the theoretical points raised by the remarkable change of colour which isopicramic acid undergoes when it forms salts with alkalis. The change is probably due to the transformation of a nitro into an isonitro group; the study of the absorption spectra may throw some light on this question.

THE ESSENTIAL CONSTITUENTS OF FOOD. Part II.

By E. Frankland Armstrong, D.Sc., Ph.D., F.C.G.I.

In the Chemical World for May an account was given of investigations which suggest the presence in food-stuffs, in minimal quantity, of certain constituents of great importance in maintaining health. In the interval Professor Hopkins, almost the earliest worker in this field, has published a full account of his experiments (*J. Physiol.*, 1912, *44*, 425—460), and further important contributions to the subject have been made by Osborne and Mendel (*J. Biolog. Chem.*, 1912, *12*, 81—89), and by Funk (*J. Physiol.*, 1912, *45*, 75—81), so that it appears desirable at this stage to supplement the account previously given.

The conclusion drawn by Hopkins that fresh foods contain, in the minutest proportions, certain "essential constituents" which enable the other materials present to be utilised, has been already noted. A study of his full paper impresses one with the extreme thoroughness of the experimental work and the care taken to exclude irregularities and secondary effects which, as workers on nutrition know, are so difficult both to foresee and to obviate.

For such experiments, the choice of the animal is of considerable importance; further, there is an essential difference physiologically between the nutrition of full-grown animals, whose only requirement is the maintenance of life, and of young animals which require above all the maintenance of the growth processes. Another point of importance, which is not always understood by the chemical critic, is the connection between the duration of the feeding experiment and the rate of growth of the animal, which last is generally expressed in terms of the period required to double the weight. Thus for example, in the case of the dog, thirty days are equivalent to a few days only in the case of rats. The full bearing of this fact will be seen later, but it is obvious that experiments with large animals must be continued over a long period. The other disturbing factors taken into account are more physiological than chemical in character and hardly call for reference here.

The experiments of Hopkins made with young rats, chosen at a stage when rapid growth is normal, show beyond question that, if purity of diet was secured, growth ceased altogether after comparatively short periods. When, however, a little milk was added to the purified diet (contributing generally some 4% to the solid matter eaten), the rats grew fast and normally.

Larger older rats were kept alive for 61 days on the synthetic diet, but flourished only indifferently, and the beneficial effect of adding the small quantity of fresh milk or an extract of mangels to the diet was very marked in their case also.

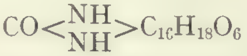
No satisfactory answer can be given as yet to the question whether prolonged maintenance is possible on synthetic dietaries. Hopkins finds that when the food has been thoroughly extracted with alcohol there is a loss of weight after quite short periods of feeding, but he is cautious to avoid giving a direct negative to the question. Osborne and Mendel, whose experiments led them to give an affirmative answer, realised the complexity of the subject, and like Hopkins they draw a distinction between the maintenance of life in adults and the maintenance of the growth processes in young rats. The artificial dietary gave less favourable results in the latter case.

Abderhalden, who is much more positive as to the success of the synthetic diet, has experimented on lines which are more open to criticism. His amino-acid material was either digested flesh or digested casein, less favourable results being obtained with the latter; these products can hardly be regarded as so thoroughly purified as the alcohol extracted materials used by other workers. The chief criticism rests on the inadequacy of the duration of the experiments with such a large animal as the dog; it is probable that a certain store of the essential constituents, which are missing from the artificial diet, is available in the body. Even rats thrive on the artificial diet for a day or two when it is first administered, and subsequently fall off as the inadequate diet is continued.

The amount of new milk required to supply the essential constituent in sufficient quantity is very small and an optimum is soon reached; this is in agreement with the work of Stepp. The addition of protein and salt-free extracts of milk solids or of yeast to the artificial diet gave precisely similar results. In the latter instance an ether-soluble fraction of the total alcoholic extract of yeast proved very efficient, showing that the valuable constituent was soluble in ether.

The facts cited bring out clearly the need of the essential constituent in the diet before normal growth can occur in young animals; they offer no clue to its nature, and Professor Hopkins is at present silent on this point. Progress in the desired direction is possibly afforded by the work of Funk, to which attention was directed in the previous article.

Pressed yeast or its alcoholic extract had been shown by Eykman to have a curative effect on polyneuritis in pigeons, and Funk has applied to an alcoholic extract of yeast the methods of purification adopted by him in the case of rice polishings. He has been successful in obtaining a somewhat larger amount of the curative substance than formerly, and his analysis shows it to be a base having the composition $C_{17}H_{20}O_7N_2$, for which he has suggested the name vitamine; it probably belongs to the pyramidine group, being analogous to uracil and thymine, and it is possibly a constituent of nucleic acid. Funk writes the formula provisionally:



$$CO\!<\!\genfrac{}{}{0pt}{}{NH}{NH}\!>\!C_{16}H_{18}O_6$$

The same curative substance has been isolated from rice polishings, yeast, and also from milk and the tissue of the brain, but no proof has been afforded as yet that its addition to a synthetic dietary, such as employed by Hopkins or Stepp, will enable growing animals to make proper use of the nutritive elements. Until this is done the connection between the two lines of research remains hypothetical. Whilst proteins and carbohydrates are undoubtably indispensable components of the diet, there is no definite information available as to the actual requirement of fat. The latest experiments of Osborne and Mendel are an important beginning in the study of this question which hitherto had baffled solution by reason of the experimental difficulties. It is only with considerable trouble that fats can be completely removed from food materials, and, as we have seen, it is not always possible to maintain animals on artificially-prepared isolated food substances.

The American workers are careful to draw a distinction between extraction of the food materials with ether and extraction with hot alcohol. The latter treatment extracts other substances as well as lipoids. Stepp, in the experiments quoted in the first article, used both ether and alcohol for extraction, and therefore removed a variety of compounds. Osborne and Mendel publish experiments in which rats were fed for nearly 200 days on a mixture of isolated and purified proteins with starch-sugar and "protein-free milk," which had been carefully extracted with ether. They state that, so far as can be judged by appearance and body weight, the rats thrive quite as well on fat-free diets as on a diet containing fat; and they claim that the experiments give positive evidence of the dispensableness of true fats for growth.

The diet used by them was not completely free from lipoids, but products which have undergone so much purification can hardly include any significant quantities of phosphatides.

The problem of rational feeding is of greater industrial importance in the case of animals than in man, since the latter is left entirely free to follow his own tastes in the matter. One of the most elusive questions which confronts the stock-feeder at the present moment is the difference in nutritive and fattening value of adjacent fields. The alluvial lands on the coast of Kent and Sussex, known as the marshes, have long been used for sheep-grazing, but although the land is rich, it is not equally fertile everywhere. Certain fields are capable of fattening throughout the summer, others which adjoin them will do no more than keep sheep in a growing condition. The facts have been recognised as a commonplace of farming for over a century; in the past the differences have mainly been attributed to the different species of grasses on the two pastures.

Hall and Russell (*J. Agric. Sci.*, 1912, *4*, 339—370) have recently made a very careful study of the two types of pastures. In general they find, contrary to the older view, that the botanical composition of the herbage is the same, but there is a difference in the habit of growth, the grasses being essentially leafy on good lands and stemmy with fewer and narrower leaves on the poor lands. Even this variation makes no difference in the proportions of fat, protein, fibre, etc., determined in the herbage. Though the soil conditions and the same floral type persist over the two fields the habit of growth and the feeding value may be very different. The two factors—botanical composition and habit of growth—are shown to be governed by a different set of conditions and to be independent.

The soils of the fattening fields produce nitrates at a somewhat higher rate and contain rather more phosphoric acid; the good fields lie higher and are somewhat better drained, and it is not difficult to see from the agricultural point of view how the difference has gradually come about.

The authors make no attempt to account for the differences in the food value, beyond pointing out that the ordinary methods of chemical valuation are clearly inadequate for dealing with pasture grasses. It is at least permissible to consider whether some essential constituent in minimum quantity may not be the determining factor. Before this question can be answered a good deal more remains to be determined as to the influence of the habit of growth on the proportion of certain rarer constituents of plants which might be supposed to act in virtue of their stimulating the animal digestive organs.

Far too much has, perhaps, been made by the extreme advocates of certain forms of diet, of the possible importance and special nutritive influence of these "essential constituents" in the human dietary. They are undoubtably present in a variety of the common foods, so that their partial absence from white bread, for example, can only be of any practical importance when bread forms a very large proportion of the total dietary. It is to be supposed that the adult human will contain a considerable reserve of the vitamines, though, on the other hand, the prevalence of scurvy on sailing ships indicates that this reserve is capable of being exhausted. Any progress made on the chemical side, which will show how to obviate the ravages of scurvy and allied diseases, will be of lasting benefit to humanity and more than justify the labours of the research.

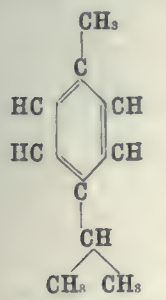
Progress of knowledge in this field will also assist very materially in the rational feeding of young children who are exposed to grave dangers owing to the increasing use of dried proprietary foods, from many of which the vitamines are lacking. All these aspects of the subject will no doubt soon receive attention.

THE TERPENES.

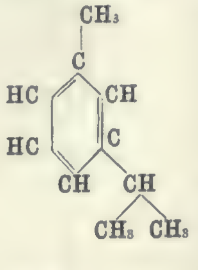
By PROFESSOR J. B. COHEN, B.SC., PH.D., F.R.S., UNIVERSITY OF LEEDS.

THE terpenes are hydrocarbons of the formula $C_{10}H_{16}$ which are found widely distributed and in considerable quantities in the essential oils of plants, especially of conifers. They occur in different parts of the plant, sometimes singly, sometimes two or more together, and frequently associated with sesquiterpenes, $C_{15}H_{24}$, and with allied compounds containing oxygen such as *thymol* and *carvone* $C_{10}H_{14}O$, *cineol fenchone*, *thymol* and *camphor*, $C_{10}H_{16}O$, *terpineol* and *borneol* $C_{10}H_{18}O$., and *menthol* $C_{10}H_{20}O$. Gutta-percha and rubber belong to the same category.

The terpenes are mainly liquid at the ordinary temperature, with characteristic odours of an agreeable aromatic kind, of which lemon oil and turpentine oil are typical. They boil without decomposition at 155—185°, possess a high refractivity and low specific gravity, and do not mix with water. Chemically they are termed *unsaturated*, because they unite directly with bromine, the halogen acids, nitrogen trioxide and tetroxide, nitrosyl chloride, etc. They are, moreover, optically active, and are often found in two modifications obtained from different sources, one being dextrogyrate and the other laevogyrate. As the study of plant products added new members to the list of terpenes it became necessary to find methods of purifying them and also to discover characteristic chemical features by which they could be identified. Sir William A. Tilden was the first to attempt a systematic classification of the terpenes. They were divided into three groups, the turpentine group, the lemon oil group or citrenes, and sylvestrene from *pinus sylvestris* was placed in the third group. In 1887, eight members of the family were known, but the number has since increased until at the present time it has reached about twenty.



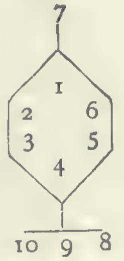
Para-cymene.



Meta-cymene.

They have been grouped into two large classes, the monocyclic and the bicyclic terpenes. Both classes may be transformed into (and are therefore closely allied to) either para- or meta-cymene.

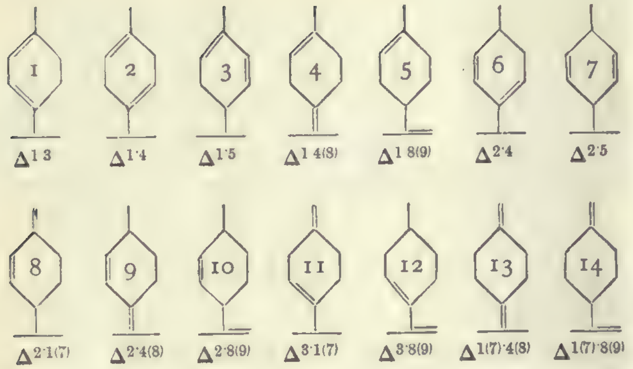
The monocyclic group are characterised by uniting readily with two molecules of hydrogen chloride or bromide, or bromine, without undergoing any fundamental change of structure, whereas the bicyclic compounds unite with one molecule in the first instance, whilst a second molecule of these two reagents will induce a far-reaching change in the molecular framework which will be discussed later. It is for this reason that the first group of compounds may be regarded as containing two ethylene linkages, or may be described in other words as dihydrocymenes. Considered as derivatives of the same saturated parent hydrocarbon *menthane*, $C_{10}H_{20}$, the group may also be termed *menthadienes*. This is the modern term of nomenclature and the position of the double bond is indicated by the Greek Δ followed by the first number of origin of the bond, referred to one or other of the 10 carbon atoms of the ring and side-chain. In the case of the para-menthadienes in which the methyl and isopropyl groups are indicated for brevity by a vertical line and an inverted T the numbering of the ring and side-chains will be as follows :



The theoretically possible p-menthadienes are fourteen in number, as shown on the next page.

Through the investigations of Wallach, Tiemann, Semmler and others, *limonene* of oil of lemons has been identified with No. 5, *terpinolene* with No. 4, α and β *terpinene* with No. 1 and No. 11 respectively. The first three can be obtained by the action of acids on pinene. The formulæ of α- and β- *phellandrene* from fennel oil (*phellandrium aquaticum*) is represented by No. 3 and No. 8, and an artificial *menthadiene* synthesised by Perkin by formula No. 12.

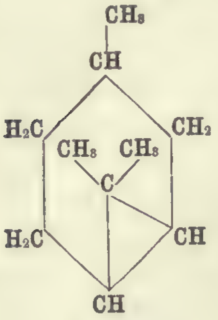
The second or bicyclic group are derived from



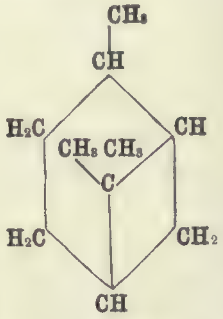
$\Delta^{1\cdot 3}$ $\Delta^{1\cdot 4}$ $\Delta^{1\cdot 5}$ $\Delta^{1\cdot 4(8)}$ $\Delta^{1\cdot 8(9)}$ $\Delta^{2\cdot 4}$ $\Delta^{2\cdot 5}$

$\Delta^{2\cdot 1(7)}$ $\Delta^{2\cdot 4(8)}$ $\Delta^{2\cdot 8(9)}$ $\Delta^{3\cdot 1(7)}$ $\Delta^{3\cdot 8(9)}$ $\Delta^{1(7)\cdot 4(8)}$ $\Delta^{1(7)\cdot 8(9)}$

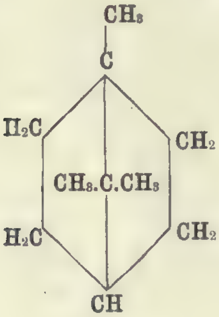
the following saturated parent hydrocarbons by the removal of two hydrogen atoms and consequent formation of one ethylene linkage:



Carane.



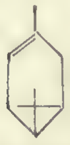
Pinane.



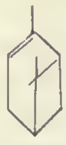
Camphane.

The terpenes themselves are termed *carene*, α and β *pinene* and *bornylene*.

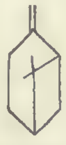
In this group, carene, α and β pinene and bornylene may be represented as follows, the vertical line indicating the methyl group and the crossed lines the $CH_3.C.CH_3$ group of the inner ring.



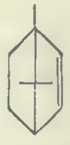
Carene.



α Pinene.



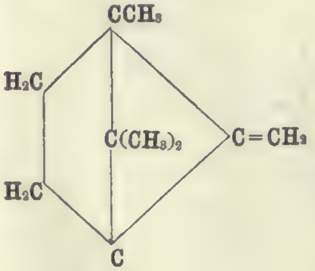
β Pinene.



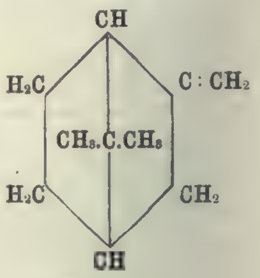
Bornylene.

There are in addition several derivatives of ortho- and meta-menthadienes, both natural and artificial, which will be referred to presently, and also the following, the structure of which is not in all cases definitely established.

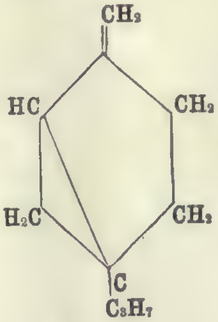
It would take too long to discuss in detail the slow and often intricate steps by which the natural hydrocarbons were gradually identified with members of the one or other group and the exact position of their constituent atoms determined. The evidence has been derived in the first instance from the cleavage products, for the knowledge of which we are indebted mainly to the masterly researches of Professor Wallach, and in the second place from their synthesis, the brilliant achievement of Professor W. H. Perkin and his co-workers.



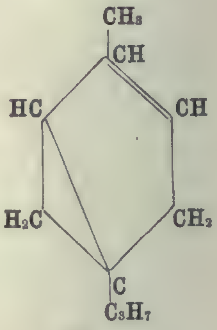
Camphene?



Fenchene?



Sabinene.



Thujene.

We will now attempt briefly to indicate the direction in which the combined labours of Wallach and Perkin have woven out of the tangled thread of facts a fabric in which the parts have been shown to hang simply and naturally together. We will begin with limonene or its inactive representative, *dipentene*, the structure of which was the first to be determined and the synthesis the first to be achieved. A general property of unsaturated carbon atoms forming an ethylene bond is to take up hydroxyl groups on oxidation, followed by separation of the carbon atoms. Now there are two unsaturated alcohols or menthenols which are directly related to dipentene and in which the position of the hydroxyl group has been ascertained. The one is known as *terpineol*, the other as *dihydrocarveol*. In both cases two hydroxyls are taken up on oxidation, giving two distinct trihydroxy-derivatives. On further oxidation the ring is broken in the former case and the side-chain in the latter, yielding respectively an open-chain compound and a benzene derivative, both of known structure.

(*To be continued.*)

"Action of Enzymes."—Professor Bayliss will deliver eight lectures on Fridays at 5.0 p.m., beginning on October 25th, at University College, free to internal students of the University and others specially admitted.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

SCIENTIFIC METHOD IN CELLULOSE INVESTIGATION.

By C. F. CROSS.

THERE has recently been published under the title "Die Einwirkung von Wasser und Natronlauge auf Baumwollcellulose" (Berlin, 1912, Borntraeger), an experimental investigation of some of the fundamental constants of cellulose. The author, Dr. M. Robinoff, applies the reactions of cellulose with alkaline cupric oxide in diagnosis of the constitutional variations impressed upon typical celluloses by serially regulated treatments. These reactions, which have been selected and methodised by C. G. Schwalbe in their particular relation to cellulose investigation, are of obvious *à priori* value, and this present investigation is an important confirmation of their diagnostic capabilities.

Thus, to select a convincing case, the author's numbers afford sufficient proof that cellulose is constitutionally modified by contact with highly dilute acetic acid (0·1 % $C_2H_4O_2$) at ordinary temperatures, and that by contact with cold $N/_{10}HCl$, as, for instance, in the "souring" operations of textile bleaching, there is a progressive modification with the duration of the contact. No other method yet disclosed has been able to diagnose constitutional changes such as these, which are certainly slight, and to Schwalbe, therefore, we owe a contribution of present and potential importance.

Robinoff follows Schwalbe in avoiding theoretical speculative treatment of the subject-matter, and this restraint is no doubt deliberate. On the other hand, the positive purpose underlying this and other investigations of Schwalbe, or inspired by him, is to accumulate quantitative data, and we may refer the reader to our two previous articles in this Journal (pp. 84 and 223) under the title of this present communication, to show that our suggestions have been anticipated in this particular direction.

What we also set forth in our suggestions was the view that any set of quantitative data require establishing by convergent verifications. This for the simple reason that cellulose is its own standard. Cellulose requires treatment as a system *sui generis*, and not as a detached individualised molecular unit, comparable in all respects with the general range of carbon compounds. Whether clearly recognised as a postulate or not, investigators are constrained by the exigencies of laboratory experience to work on this basis, and it is implicitly recognised by Robinoff.

All the derivatives of cellulose present themselves in series, with gradations which apparently increase in number with the refinement of method; of these series the limiting cases are the assumed individuals, which are only really individual in the sense of identical ratios of their component residues, which are the common stoichiometrical ratios.

The celluloses themselves present greater difficulty to the investigator than, *e.g.*, their derivative esters, if only for the reason of essential insolubility. Hence the characteristic features of methods applicable to cellulose: quantitative statistics of reactions, and measurements of physical and mechanical properties of the solids, with observations of changes of form and dimension.

In the plan of Robinoff's investigations are included treatments by water at temperatures from 100° to 213°, and by sodium hydrate solutions under an extremely wide range of graduated conditions.

The constitutional effects are measured in terms of hygroscopic moisture, and the reactions with alkaline cupric oxide (*a*) of combination, and (*b*) of reduction, and these furnish the desired convergence of correlative effect.

The author's paper must be closely studied by those who have a special, or a *specialist*, interest in cellulose chemistry.

It will interest the general reader to know that in addition to diagnosing such relatively small changes in constitution as result from contact of celluloses with highly dilute acids, the author is also able to show that their constants, and, therefore, constitution, are definitely modified by the papermaker's beating process. The results on this point are worthy of reproduction as they are of importance to a wide range of readers.

A bleached Egyptian cotton, ascertained to be "normal," was employed, and the following numbers are recorded.

Time of Beating.	Hygr. Moisture.	Copper Number.	Cellulose Number.	Corrected Copper Number.	Hydrolysis Number.	Corrected Hydrolysis Number.
0	6·27	0·51	0·29	0·22	—	—
1	6·60	0·56	0·29	0·27	3·00	2·44
4	7·87	1·07	0·58	0·49	5·12	4·05

As a comment on these results, which are of obvious significance as proof of progressive chemical action, the author adds "they confirm the supposition of certain investigators that in comminuting the fibrous celluloses (true) hydrated modifications of cellulose are produced."

We have maintained this view in accordance with the generalised conclusions from long observation, that cellulose responds to any and every treatment with reagents, however weak, by constitutional change. This has been present to us as the only adequate basis of cellulose technology, and there are current developments of extension and refinement of cellulose processes which are rapidly accumulating definite proofs of the statement. The author's contribution of proof is, however, of greater importance because it is in terms of numbers, and in the particular form of concordant and convergent verifications.

By this investigation several points are established in addition to further proof of the value of these constants of Schwalbe's methods in cellulose investigations.

The author has advanced the conception of the labile constitution of cellulose, and the precise definition of the "normal cellulose."

He has furnished a basis of precise investigation of such important textile processes as involve special purification and preparations of celluloses, more particularly the textile bleaches and "finishes," and the operations of the papermaker.

As a complementary investigation there is now required the extension of the author's observations to such structural forms of cotton cellulose, *e.g.*, yarns and papers, as allow comparison of constants of strength and elasticity. In due course the method will be extended to the diagnosis of other celluloses, and when the results are correlated with the constants of characteristic synthetic reactions and of the physical properties of the resulting derivatives, we shall have the foundations of a systematic chemistry of cellulose, *sui generis.*

PASSIVITY OF IRON AND NICKEL.

By THOS. J. KIRKLAND, B.Sc.

METALS are said to be in the "passive state" when they are not acted on by reagents, which in the ordinary way attack them.

The magnetic metals, *e.g.*, iron and nickel, most easily assume the "passive state," and it is with them that this article deals. The investigation of the particular circumstances under which iron becomes passive is of considerable importance, as a thorough understanding of this question would throw much light on the problem concerning the rusting of iron.

Pure iron and nickel that have been dipped in ordinary concentrated nitric acid and then transferred to dilute nitric acid are unattacked by the latter, so long as the strength of the acid does not fall below a certain standard.

In the case of iron, it is found that when the dilute acid is not more than 50% water, the iron shows signs of passivity, and these signs increase as the percentage of water in the acid decreases, until the acid contains 10% water, when the iron becomes absolutely passive. In the case of nickel very similar results are obtained. Iron that has been left immersed in the concentrated nitric acid for 36 hours is found to have acquired a greater degree of passivity than that which has been merely dipped in the acid and immediately withdrawn; iron which has been treated in this way is almost completely passive when put into a 60% solution of nitric acid.

A roll of iron or nickel wire partly dipped in strong nitric acid, and then completely immersed in dilute nitric acid, can with care be made to develop no gas, showing the whole of the roll to be in the passive state.

If, after the iron or nickel has been placed in the strong nitric acid, it be rubbed, no signs of passivity are noticed.

Wrought iron is generally less passive than steel; passivity seems to increase as the percentage of carbon increases, and to decrease with the rise of temperature.

Various attempts have been made from time to time to account for the passivity of iron and other metals.

One of the commonest suggestions is that the iron or nickel becomes coated with a film of oxide, which protects the metal from further action. This theory is supported by the fact that Fe_2O_3, H_2O and $FeOFe_2O_3$ are insoluble in cold nitric acid, but it does not account for the whole of a strip of iron becoming passive when only part of it is immersed in the strong nitric acid. The theory that a basic ferric nitrate is the cause of passivity breaks down for the same reason. Varenne has suggested that passivity is due to a layer of gas protecting the surface of the metal. If this is the reason, why is wrought iron less passive than steel, and why should 50% nitric acid attack it, and not 90%?

It will be seen that the above theories do not account for all the facts, hence we must look for a wider explanation. The results obtained can be accounted for by assuming that passive iron is an allotropic modification of ordinary iron, and that, in order to convert iron to the passive state, some substance, such as strong nitric acid, is necessary. The process of passivifying is always electrolytic, and when no external current is used, one is produced from different parts of the surface.

Hence, if a mass of iron could be converted into the allotropic modification throughout, and not merely on the surface, the problem of iron rusting would be solved.

The Camphor Industry in Formosa.—The following information is from the report by H.M. Consul at Tamsui (Mr. J. B. Rentiers) on the trade of Formosa in 1911, which will shortly be issued:—

The export of camphor (a Government monopoly) showed a decrease of 872,554 lbs. in 1911. The quantities shipped to the various countries were as follows:—

	Lbs.		Lbs.
Germany ..	2,374,666	British India ..	126,000
United States ..	2,039,500	Austria-Hungary ..	33,333
France	562,267	Japan	5,952
United Kingdom	472,000		
		Total ..	..5,613,718

The estimated output of refined camphor by the Monopoly Bureau's refinery during 1911 was 7,267,000 lbs.

The number of owners of crude camphor works was 14, but the number of works exceeded this. It is stated that no new licences will be issued during 1912 as the authorities still hold surplus stocks brought over from two years ago. The estimated receipts of crude camphor and camphor oil for the financial year 1911 were 6,264,000 lbs. and 7,272,000 lbs. respectively. These quantities were received, though in part after the turn of the year, the late receipts being brought over to the following year. The prices paid by the Monopoly Bureau for crude camphor and oil were:—

	Per 100 Kin.*				
	Yen	sen.	£	s.	d.
"A" quality	47	90	4	17	9
"B" quality	44	90	4	11	8
"C" quality	41	90	4	5	6
Camphor oil	24	20	2	9	8

* 132·277 lbs.

The estimated demand in Japan for Formosan camphor during 1911 was 3,280,000 lbs., to be extracted from the oil sent over. The quantity of camphor sent was very small. This demand is expected to increase considerably this year in consequence of the newly-established manufacture of celluloid.

The improved refining machinery installed by the Bureau last autumn is said to give satisfactory results, producing camphor to the amount of 48 % of the weight of oil used; this camphor is of superior quality, viz., 93 % pure containing only 2 % of oil and 5 % of water. The distillation is effected by steam heat, steam being also forced through the oil during distillation.

The Government has since 1906 encouraged the planting of camphor trees by distributing seedlings gratis. Over 3,000,000 plants were distributed in 1911. As the result of experiments carried on for five years, the Bureau will commence the distillation of camphor from leaves on a practical scale this year. A considerable area has been afforested for this purpose.—*Board of Trade Journal.*

UNIVERSITIES AND COLLEGES.

THE DEPARTMENT OF AGRICULTURE OF THE UNIVERSITY OF CAMBRIDGE.

By PROFESSOR T. B. WOOD, M.A., DRAPERS PROFESSOR OF AGRICULTURE.

AGRICULTURE is essentially a modern subject of study in Cambridge. The first beginnings date back only twenty years, when an informal Committee of University Professors and County Council representatives, called the Cambridge and Counties Agricultural Education Committee, determined to organise agricultural teaching in Cambridge.

PART OF THE BIOLOGICAL LABORATORY IN THE SCHOOL OF AGRICULTURE.

Funds were provided by grants from several of the East Anglian County Councils and from the Board of Agriculture. The moving spirit of the committee was Dr. G. D. Liveing, then Professor of Chemistry in the University, who controlled the financial arrangements and gave the use of a wing of the basement in his new laboratory.

The committee possessed only one full-time officer, the late Henry Robinson, M.A., of Downing College, who was appointed Secretary and Lecturer in Agricultural Chemistry. Mr. Robinson survived his appointment only one year, and was succeeded in January, 1894, by the writer of this article.

For the first few years the University, for lack of funds, was unable to give official support to the agricultural teaching, though the Professors of Botany, Geology, and Physiology joined Professor Liveing in admitting agricultural students to their laboratories. In 1894 the University instituted a Diploma in Agriculture and appointed a syndicate to take charge of the necessary examinations.

At first the number of students was small, varying between ten and twenty, most of whom were scholars of the contributing county councils, who did not become members of the University.

The committee, acting in conjunction with the county councils and with various agricultural

* * *

organisations, as for instance the Norfolk Chamber of Agriculture, endeavoured to awaken interest in their work by carrying out field experiments at local centres, of which over fifty were in active progress when the University officially took over the work in 1899. The first recognition from the University was brought about through the generosity of Sir Walter Gilbey, who provided funds for the foundation for twenty-one years of a Lectureship in the History and Economics of Agriculture. This was followed in 1899 by further benefactions from Sir Walter Gilbey and from the Drapers' Company, which enabled the University to create for ten years a Professorship of Agriculture and a Lectureship in Agricultural Chemistry. The Drapers' Company have since extended the period of their benefaction to twenty years and the Drapers Professorship is now assured until 1919. They have also provided part of the stipend of a second Professorship of Agricultural Botany.

At the time of the creation of the Professorship, the University instituted a Board of Agricultural Studies, which since 1899 has directed all the affairs of the University Department of Agriculture, having succeeded the original informal committee and the agricultural examination syndicate. The Board consists of the Vice-Chancellor and several other *ex-officio* members, together with members appointed by the University on the nomination of the Council of the Senate, the Board itself, and the contributing county councils.

When the University department first came into existence its headquarters were in the wing of the basement of the Chemical Laboratory, lent by Professor Liveing. Another room was also lent by the Professor of Botany. The Cambridge County Council allowed the use of the garden of their Technical Institute. This was given up in 1900 when Mr. W. A. Macfarlane Grieve, of Clare College, gave to the University the use of Burgoyne's Farm, Impington, rent free for nine years. This farm served an excellent purpose, but was vacated in 1909 for Gravel Hill Farm, which is much larger and nearer to the colleges and the laboratories.

Part of the Chemical Laboratory in the School of Agriculture.

In 1905 a movement was started by the late Duke of Devonshire, then Chancellor of the University, to collect £20,000 to build an agricultural laboratory. This project met with the hearty support of the Drapers' Company, who promised to contribute £5,000 if other £5,000 could be raised within a certain time. £12,000 had been collected when the late Chancellor died. The remaining £8,000 was collected by a Committee of the Cambridge University Association, presided over by the present Duke of Devonshire. The School of Agriculture was built during the year 1909 by Mr. W. Sindall, of Cambridge, from designs prepared by Mr. Arnold Mitchell, F.R.I.B.A., and was formally opened on April 28th, 1910, by the Duke of Devonshire. The building is 100 ft. long by 40 ft. wide, and stands in the old Downing Park, which was purchased from

Downing College some years ago by the University. It is conveniently situated adjoining the Botany School and the Sedgwick Museum of Geology. The Drapers' Physiology building is now in course of erection near by, and a Forestry School is also in contemplation.

THE HOMESTEAD AT THE UNIVERSITY FARM.

When the plans for the School of Agriculture were prepared the number of students was about forty and the building was designed to accommodate two classes each of about fifty. It consists of a basement, three floors and attics. The basement contains rooms for storage, for the preparation of samples, and for machinery. On the ground floor are situated the large lecture theatre, which is capable of seating 150, the library, the office, the advisory department, and private rooms for the University Lecturer in Agriculture, and for research in physical problems.

SOUTH FRONT OF THE SCHOOL OF AGRICULTURE, SHOWING THE WEST END READY FOR EXTENSION.

The first floor is devoted to biological work. It contains a small lecture-room for the advanced class; a large biological laboratory, and private rooms for the Professor of Agricultural Botany, the University Lecturer in Agricultural Physiology, the Lecturer in Agricultural Zoology, and two rooms for research work. The second floor is occupied by the Drapers Professor. It contains a small lecture-room for the advanced class, a large chemical laboratory, with preparation and balance rooms, and three rooms for chemical research. The attics comprise one work-room, a dark-room for photography, a greenhouse, and a large space for storage. There is also some accommodation on the roof for pot experiments.

The illustrations show the large biological laboratory, and the large chemical laboratory; there is also an efficient library.

The improved accommodation provided by the new building at once resulted in a rapid increase in the number of students. The elementary class, which is largely composed of young landlords taking agriculture as one of the subjects for the ordinary degree, now numbers between fifty and sixty, and stretches the laboratory accommodation to its utmost.

The advanced class varies between thirty and forty, and consists of senior students, many of whom have taken an honours degree in Natural Science before joining the Agricultural Department, and intend to take up agriculture or some branch of agricultural science as a profession. After obtaining their diploma, these men obtain posts in England, or enter the agricultural services in India, Egypt, the West Indies, South Africa or elsewhere.

The instruction given in the School of Agriculture consists of lectures on agriculture, agricultural chemistry, physics, botany, physiology, zoology, geology, and other sciences bearing on agriculture. The lectures are followed by practical work in the laboratories or on the University Farm.

The staff consists of the Drapers Professor of Agriculture, whose special subject is agricultural chemistry, the Professor of Agricultural Botany, R. H. Biffen, M.A., who has for the last ten years devoted most of his attention to the breeding of improved races of cereals, the University Lecturer in Agriculture, K. J. J. Mackenzie, M.A., A.S.I., who is also director of the University Farm at Gravel Hill, the University Lecturer in Agricultural Physiology, F. H. A. Marshall, Sc.D., whose researches in the physiology of reproduction are well known.

The Field Laboratories.

There are also lecturers in zoology, Cecil Warburton, M.A., Zoologist to the Royal Agricultural Society; in physics, R. H. Adie, M.A., B.Sc., lecturer of St. John's College; in crop husbandry, A. Amos, M.A., Bursar of Downing College. The staff has recently been increased by the appointment of a University Lecturer in Statistics, whose lectures will be intended for students of both agriculture and economics.

There are also one or more demonstrators in each subject, who assist in the practical teaching both in the laboratory and on the farm.

When the Board of Agricultural Studies decided that the Impington Farm was too small and too far from Cambridge, they were fortunate in getting the offer of Gravel Hill Farm. This farm belongs to Trinity College and consists of 200 acres of land, rather more than half of which is arable. It lies between the Huntingdon and Madingley roads and partially surrounds the Observatory. It is the nearest agricultural land to the town and is only about a mile from the School of Agriculture. The soil is partly gravel and partly stiff boulder clay.

The farm is run as the laboratory of the Lecturer in Agriculture for the illustration of his teaching. It has also to accommodate the research work of the Professor of Agricultural Botany and other members of the staff who require to grow plants or animals on a large scale. A small area is also devoted to the poultry and rabbit-breeding experiments of the Professor of Biology.

Most of the arable land is farmed for teaching purposes, the crops grown being wheat, barley, oats, rotation hay, potatoes, mangels, etc. A herd of pedigree milking shorthorns is kept; also flocks of Suffolk sheep, and a small herd of large white pigs.

The accompanying illustration shows the farmhouse and some of the buildings. The bull in the centre of the photograph, Cantab Seraphino, is a milking shorthorn bred on the farm. The following illustration shows Professor Biffin's bird-proof cage for cereal-breeding experiments. In the foreground are potato seedlings, and to the left a number of fruit trees also under experiment.

Besides the farm, the Department is part-owner of the Field Laboratories, a flourishing institution for the investigation of all kinds of problems concerning animals. It comprises ten acres of land on the Milton Road, about two miles from the School of Agriculture. The superintendent is Mr. Cyril Fox, lately on the staff of the Tuberculosis Commission. The illustration shows in the foreground several small animal houses. The larger house on the right is the laboratory.

A Corner of the Plant Breeding Ground at the University Farm.

Negotiations are now practically complete between the University and the Development Commissioners, as a result of which there will be established in Cambridge, in connection with the Department of Agriculture, an advisory department for the Eastern Counties, and two Research Institutes, one for plant breeding, the other for animal nutrition. This will necessitate the extension of the School of Agriculture to nearly twice its present size, and the acquisition of another farm for plant breeding.

THE CHEMISTRY OF THE LEAD CHAMBER PROCESS.

By E. JOBLING, B.Sc., A.R.C.S.

ALTHOUGH the Lead Chamber Process has been technically employed for over a century and a half, chemists cannot yet be said to have obtained a full insight into its mechanism or to be agreed upon the relative importance of the various reactions involved. Even after many years' research, the evidence is so conflicting and the conclusions therefrom so divergent that a glance at the literature of the subject leaves one in a condition of bewildering uncertainty. It is the purpose of the present article, not so much to give an account of all the theories that have been brought forward, as to indicate the trend of modern hypothesis in this direction.

The theory of Lunge is deserving of consideration, partly because of the authority of this investigator, but more especially by reason of the very interesting controversy to which it has given rise. According to Lunge's earlier views of 1885, the reduction and oxidation of N_2O_3 were considered to be the most important features, in contradistinction to the usual acceptation in which the principal rôle was ascribed to NO_2. Nitrosyl-sulphuric acid was still considered to be the intermediate compound. In the presence, then, of oxygen and water, SO_2 reacts with N_2O_3, yielding nitrosyl-sulphuric acid, from whose decomposition the sulphuric acid results.

$$2SO_2 + N_2O_3 + O_2 + H_2O = 2SO_2(OH)(ONO)$$
$$2SO_2(OH)(ONO) + H_2O = 2H_2SO_4 + N_2O_3.$$

In this form the theory goes back to that of Davy (1812), subsequently upheld among others by Gmelin and Winkler, according to which the intermediate formation of "chamber-crystals" is essential to the working of the process. Now, however, by dint of Raschig's objections, an additional intermediate substance is postulated and NO_2 is fallen back upon as the active oxide of nitrogen (1906). By the interaction of SO_2 and NO_2 in the presence of water, a compound stated to be sulphonitronic acid is produced,

$$(1)\ SO_2 + NO_2 + H_2O = SO_2(OH)(NOOH),$$

and it is this which, by contact with oxygen or further NO_2, is decomposed to nitrosyl-sulphuric acid.

$$(2)\ 2SO_2(OH)(NOOH) + O = H_2O + 2SO_2(OH)(ONO).$$
$$(3)\ 2SO_2(OH)(NOOH) + NO_2 = H_2O + 2SO_2(OH)(ONO) + NO.$$

The nitrosyl-sulphuric acid then liberates sulphuric acid in either of two ways, viz.,

$$(4)\ 2SO_2(OH)(ONO) + H_2O = 2H_2SO_4 + NO + NO_2,$$
$$(5)\ 2SO_2(OH)(ONO) + SO_2 + 2H_2O = H_2SO_4 + 2SO_2(OH)(NOOH),$$

and whilst the sulpho-nitronic acid of the last equation suffers the changes of equations (2) and (3), the NO in each case is reoxidised to NO_2. It is thus seen that the theory, like the earlier ones mentioned, is governed by the idea that all sulphuric acid formed in the chambers must pass through the "chamber-crystal" stage.

Raschig, on the contrary, rejects nitrosyl-sulphuric acid as the transition phase, and even denies its existence in the sulphuric acid of the concentration to be found in the chambers. Further, NO_2 is dispensed with as the catalyst between the SO_2 and the oxygen. The effective nitrogen compound is considered to be nitrous acid (anhydride N_2O_3), whilst the function of the intermediate substance is ascribed to nitrosi-sulphonic acid. Accordingly, nitrous acid reacts with SO_2 to produce blue nitrosi-sulphonic acid; this breaks up under the influence of more nitrous acid into sulphuric acid and NO, and then the latter is converted into N_2O_3 which dissolves to nitrous acid in the water sprayed into the chambers. The reactions are given in the following equations:—

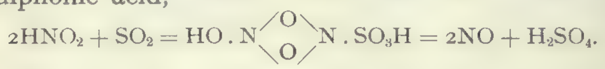
$$(1)\ NO.OH + SO_2 = NO.SO_2.OH.$$
$$(2)\ NO.SO_2.OH + NO.OH = 2NO + HO.SO_2.OH.$$
$$(3)\ 2NO + O + H_2O = 2NO.OH.$$

The theory has twice undergone revision, but as confusion would only result from a discussion of the earlier stages, attention will be confined to Raschig's latest opinions. These are substantially as have already been described, with the exception that an additional step is introduced in the reaction between the nitrous and the nitrosi-sulphonic acids by the assumption of another but less important intermediate substance, viz., nitroso-sulphonic acid. The complete process can then be represented by the following equations:—

$$\begin{array}{lll}
(1) & NO.OH + SO_2 & = NO.SO_2.OH. \\
(2) & NO.OH + NO.SO_2.OH & = NO + HO.NO.SO_3H. \\
(3) & HO.NO.SO_3H & = NO + H_2SO_4. \\
(4) & 2NO + H_2O + O & = 2NO.OH \\
\hline
 & SO_2 + O + H_2O & = H_2SO_4.
\end{array}$$

The occasional production of "chamber-crystals" is attributed to a secondary reaction in which the nitrosi-sulphonic acid is oxidised by the traces of nitric acid produced by the oxidation of NO. Similarly the "purple acid," sometimes observed in the Glover tower, is identified with the nitrosi-sulphonic acid; and to remove this source of loss, Raschig suggests that the nitric acid, usually supplied to the Glover tower to make up for the losses of nitrogen in the system, should be added instead to the Gay-Lussac tower and so oxidise the nitrosi- to nitrosulphonic (nitrosyl-sulphuric) acid. It will be noticed, too, that whilst the decomposition of "chamber-crystals" yields a bright yellow mixture of gases, Raschig's equations involve the liberation of a large proportion of colourless NO, and so fit in with the observation that the gases are almost colourless in the chambers. A further advantage of the theory lies in the explanation it gives of the losses of nitrogen with which the process is associated, for recently the delinquency has been traced to the presence of ammonia in the resulting acid, and this theory readily accounts for, in fact it predicted the explanation of, this loss.

Naturally, such views have not met with the whole-hearted acceptance of chemists. Instead, the old Lunge-Raschig controversy appears to have been replaced by another no less interesting in which Raschig seeks to defend the position he has adopted. Divers, for instance, has suggested several modifications. In his latest, he considers that nitroso-sulphonic acid is not qualified to play the rôle of an intermediary and declares nitrosi-sulphonic acid to be incapable of existence. Whilst supporting Raschig in his selection of nitrous acid as the active nitrogen-containing body, he postulates only one intermediate substance, in this case nitroxy-sulphonic acid,



$$2HNO_2 + SO_2 = HO.N\left\langle\begin{matrix}O\\O\end{matrix}\right\rangle N.SO_3H = 2NO + H_2SO_4.$$

Reynolds and Taylor (see May number of CHEMICAL WORLD) agree with Divers in rejecting nitrosi- and nitroso-sulphonic acids, but in their sweeping condemnation of all "intermediates" involve Divers' nitroxy-sulphuric acid in the general ruin.

Strangely enough, this reversion to the old ideas of Berzelius, who favoured the principle of direct action, is not confined to these investigators alone. Trautz, in attempting to combine the usable parts of both the Lunge and Raschig theories, is led likewise to disclaim all intermediate reactions. Wentzki, Weber, Riedel and others arrive at the same conclusion. Two primary objections are urged by these investigators against the above-mentioned "intermediate" theories: first, that the "intermediate" must be supposed to exist under conditions which determine its immediate decomposition, and secondly, that owing to the non-reversibility of the chamber process in consequence of the powerful affinities of the reacting molecules, it is difficult to see how these strong attachments can be temporarily suspended in order to permit of the formation of quite unstable intermediate substances. Such objections are considered fatal to all theories save that, known as the "Natural" theory, which asserts that the interaction of the constituent gases proceeds directly, the nitrogen oxides being introduced merely to accelerate the normally slow combination for intensive industrial application.

Sufficient has been written to give some conception of the density of the mist of uncertainty with which the subject is enveloped. One can only say, in a general way, either that direct interaction of the reacting gases occurs, or that the transformation of SO_2 into sulphuric acid takes place through the successive production and decomposition of complex nitrogen-sulphonic acids, the precise constitution of which still remains unexplained.

Metric System in Venezuela.—It is reported that Venezuela has officially adopted the metric system.

CURRENT LEGAL TOPICS.

By W. JAGO, F.I.C.

AN account was given in the August number of this Journal (page 269) of the evidence in a prosecution for flour bleaching in Lanarkshire, Scotland. The speeches of counsel on both sides were naturally based on the evidence which had been adduced, and may be passed over in order to deal with the judgment. This was delivered on Wednesday, July 24th, by Sheriff Shorman, and, so far as its salient chemical points are concerned, is summarised below.

The learned judge pointed out that the charge was one of contravening the enactment that "No person shall sell to the prejudice of the purchaser any article of food . . . which is not of the nature, substance, and quality of the article demanded." The alleged contravention consisted in the selling of flour containing 3·43 parts per million of nitrites, the presence of which nitrites was due to the flour having been bleached by peroxide of nitrogen, and that, therefore, the flour was not genuine. According to the finding of the judge this proportion of nitrites does not alter the genuineness of the flour. He further pointed out that :—

> "It is admitted that no injurious effects from such a quantity of nitrites can be proved, and it is altogether inadequate as a ground for convicting to argue that the continuous and chronic use of nitrites may injuriously affect the consumer. The mere hypothesis that injury may be done though we do not know of it is not evidence."

The evidence went to show that ordinarily flour does not take up so much nitrites as the commercially bleached sample, whereas under certain normal conditions it may take up more than the sample. If this be so, it is impossible to hold the amount of nitrites to be in itself a test of genuineness; and there is no satisfactory evidence to show that a flour has injurious effects or suffers in quality because of the presence of this amount of nitrites, or that it ceases to be genuine. On the other hand, the presence of such excess of nitrites affords reasonable ground for suspecting that the flour has been bleached. But, on the evidence for the defence, the judge decided that the sample had, in fact, been bleached by peroxide of nitrogen. The judge noted that chemical analysis showed this particular sample of flour to have little to choose between it and first-grade unbleached flour, except in this matter of nitrites, and, therefore, the sample was of the *substance* of genuine flour. The flour having been bleached, was it, in fact, genuine? The prosecution could not prove that the particular sample had caused injury to health, or that it was not capable of being used with apparently satisfactory results for the purposes for which flour is employed. . . . The addition of nitrites is not that of a new ingredient, as the evidence is that during the milling process it almost invariably occurs that nitrites are absorbed by the flour, even when the wheat is completely free. . . . The judge further found that there was no evidence that the aid of some chemical agencies necessarily destroys the character of flour. As to whether the bleaching of flour is to the prejudice of the customer, the judge remarked that "it is undoubted that this bleached flour is bought and sold as flour. Some buyers know that it has been bleached; some have no suspicion that it has been bleached; and some (and I fancy they are the vast majority) neither know nor care so long as the flour suits their purpose." As to whether or not commercial bleaching so alters flour as to render it not of the nature of flour, the prosecution were unable to produce evidence that chemical changes actually have taken place in flours which are sold in the market.

> "What is tendered is evidence by . . . 'the method of exaggerated treatment.' The prosecution witnesses argue that what they have proved takes place as the result of large doses of peroxide of nitrogen will take place proportionately in the case of small doses, and will do so even in the minutest dose. We are here in the region of circumstantial evidence, and I think something much stronger is required for a conviction than is tendered here. It is consistent with chemical law to hold that up to a certain point exposure of flour to NO_2 may have an effect on the colour, and yet may have no prejudicial effect on the valuable properties of flour, while beyond that point exposure may have an immediate prejudicial effect."

The judge pointed out that the prosecution concerned themselves with the effects of high doses of NO_2, from 5 to 60 c.c per kilo. of flour, while the witnesses for the defence confined their attention to flours as actually treated by a bleaching plant, in which the minimum treatment was 0·3 c.c. per kilo., medium 1 c.c., and maximum 1·7 c.c. of NO_2 per kilo. of flour. With these actual strengths they could find no deleterious effects produced on the flour.

> "It must be taken as a result of the evidence that commercially bleached flours cannot be proved to be different in their essential characteristics from unbleached flour. It is not a good ground for conviction that there is no evidence that the continuous and chronic use of nitrites may not injuriously affect the consumer. The prosecution are not entitled to require respondents to prove a negative."

The judge regarded the results of baking tests as being inconclusive, as if bleached flour was unsatisfactory it would certainly lose its market. The effect on rats and rabbits afforded him very little assistance. The question of the relationship between colour and other properties of flour was examined somewhat closely. The prosecution contended that "in addition to the better colour the first grade is the cream of the mill and is a better quality of flour. From a baker's point of view you get a texture, bloom, and pile in the loaf from the first-grade flour which you cannot get in the lower grade. The second lacks the flavour and sweetness that the first grade has." The judge, however, found that—

> "The fact is that undue stress is laid upon this question of whiteness as the test of flour. It is idle to suggest that colour is the only test. The baker and the housewife buy their flour mainly on their experience of its qualities as brought out in baking."

The final conclusion arrived at by the judge was that—

> "My view is that the result of commercial bleaching, so far as the evidence before me goes, is merely to alter the colour to suit the taste of the consumer without altering the nature, substance and quality of the flour so as to render it a different article. So long as the nature, substance and quality are not affected there is no law against the miller bleaching. The colour of the flours from various wheats varies, and, therefore, bleaching is resorted to to preserve uniformity."

Although the judgment was in favour of the respondents or defendants on the ground that the alleged offence had not been proved, yet the judge expressed himself as keenly alive to the motives which underlay the prosecution. In this connection he remarked:—

> "I appreciate the medical standpoint that, where there is even apprehension of danger because you are working with materials which, under certain circumstances, may produce noxious results, such processes should be prohibited. . . . I must hold that the prosecution is based on apprehended evils rather than on proved deterioration. The argument of the prosecution is an excellent one to address to the legislature, but the prosecution must prove his case."

This exhaustively argued case and carefully considered judgment are of importance and interest, not merely because of their bearing on the chemical treatment of flour by bleaching reagents, but because of the enunciation of principles which are capable of a far wider application.

It is interesting to note that all the witnesses for the prosecution seem to have ignored the view that where small quantities of a reagent are used there would probably be selective action. The reaction between nitrogen peroxide and the colouring matter of flour is almost instantaneous; while in bleaching, as at present conducted, a portion only of the colouring matter is removed. A very interesting fact in this connection was pointed out by Hehner, who showed that only about a fifth of the original nitrite in the flour remained after a fortnight, the remainder having been used up in producing alterations in the flour, among other things reacting on the amino bodies. The colour is therefore, acted on immediately; the other actions are slow, spreading themselves over a fortnight. With this difference, one would expect that until the whole of the colour has been destroyed the action on other flour constituents would be absent. One is reminded of the use of potassium chromate as an indicator in chlorine estimations. So long as any soluble chlorides are present silver chloride is formed; it is only when these have disappeared that silver chromate is produced. This point was appreciated by the judge, who pointed out that *up to a certain point* nitrogen peroxide may have an effect on colour without influencing the valuable properties of flour.

As a purely chemical matter "the method of exaggerated treatment" deserves somewhat careful examination. Moore explained his position in the statement that he formed his opinions on the effect of low strength of gas by deductions based on the results of a strong bleach. "He had no other way of getting the information, and it was the usual method followed by the chemist. It was a just inference." Ballantyne, however, absolutely traversed this issue by the assertion that "it was neither scientifically nor chemically accurate to infer . . . that because certain results were obtained by using a particular power, therefore like proportionately smaller results would be obtained by using a lower power." Obviously, if among the reactions which occur there is any selective action, then the effects of the two cannot be the same. In other words, if 60 c.c. of nitrogen peroxide be added respectively to 1 kilo. and 60 kilos. of flour and the resultant products or effects be isolated or otherwise tested, they would be found to be totally different in nature and character in the two cases.

Perhaps one of the chief exponents of the "exaggerated method" is Dr. H. Wiley, of America, who has carried the theory to its logical conclusion. In a paper on "Preservatives" which appeared in *Proc. Amer. Phil. Soc.*, *47*, 302, the subject is dealt with fully. The writer proceeds to show "the fallacy of the argument that small quantities of an injurious substance are not injurious." As an illustration he plots some curves in order to show graphically the effect of an injurious substance from the fatal dose to the vanishing point. From this he deduces the principle that "it is easy to show by mathematical data that no matter how small the quantity of an injurious substance or preservative is it will still produce an injurious effect, which may be infinitely small if the dose be infinitely small." Probably the opponents of Dr. Wiley's view would not state their case in the same way as he puts it. They would prefer to say "certain substances are injurious in excessive quantities, and harmless, or even beneficial, in moderate and proper quantities." It is possible to place this dictum of Dr. Wiley to the direct test of one or two concrete examples. Thus, if it were possible to ingest 1,350 gms. per day of dried food constituents it would prove highly injurious, and soon fatal to the average man; and consequently, half that quantity, 675 gms., would be just half as injurious. Yet this latter is simply the standard dietetic requirement of an average man. Therefore, a man who had always consumed a normal amount of food would have been half-killing himself for the whole of his life. Again, pure oxygen when breathed alone would soon act as a poison under ordinary circumstances, and certainly would be a highly injurious substance. Then applying the mathematical rule, an atmospheric 20 % mixture of oxygen must be just one-fifth part as injurious as the pure gas. Or taking what is probably a yet more forcible example, concentrated hydrochloric acid is a virulent and almost immediately fatal poison. The swallowing of even a moderate quantity might cause death by its action on the mucous membrane of the stomach. The concentrated acid is, therefore, an injurious substance, yet a dilute solution of it (1 in 500) is a necessary constituent of the fluids of the stomach, or gastric juice. That is to say, nature is continually secreting in the stomach a fluid which is harmful to the extent of 0·2 % of the injurious effect of concentrated hydrochloric acid. Most chemists will be of opinion that the mathematical rule is not supported by facts, and will endorse the finding of the judge "that up to a certain point" a substance "may have no prejudicial effect . . . while beyond that point" it "may have an immediate prejudicial effect."

The final remarks of the judge to the effect that possibly an appeal should be made to the legislature are significant. Action in this direction seems to be in the air, and it may be well for chemists to consider what should be their attitude on the general question.

Mercury Industry.

The following table gives the world's production of mercury, in metric tons of 2,204·6 lbs., for the years 1903-10. For foreign countries the quantities given are partly from the corrected figures of the Seventeenth Annual Issue of Comparative Statistics, compiled by the Metallgesellschaft, Metallurgischen Gesellschaft A. G. and the Berg- und Metallbank Aktiengesellschaft, of Frankfort-on-the-Main, Germany; for the United States the figures are those of the United States Geological Survey; and for Spain for 1907 and 1908 they are those of United States Consular Agent A. E. Carleton:—

Countries.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
United States	1,237	1,188	1,036	892	734	672	717	701
Austria-Hungary ..	575	550	570	577	610	630	609	694
Italy	313	357	369	418	423	630	771	800
Russia	362	332	318	210	130	49	7	4
Spain	968	1,130	853	1,567	1,210	1,065	1,000	1,000
Mexico	188	190	190	200	200	200	200	[illegible]
Total	3,643	3,747	3,326	3,864	3,307	3,296	3,304	3,399

NOTE.—The Italian and Spanish figures for 1910 and the Mexican figures are partly estimated.—*Chamber of Commerce Journal.*

CHEMICAL ENGINEERING.

THE ELECTROLYTIC COPPER REFINING INDUSTRY.

By JOHN B. C. KERSHAW, F.I.C.

INTRODUCTION.

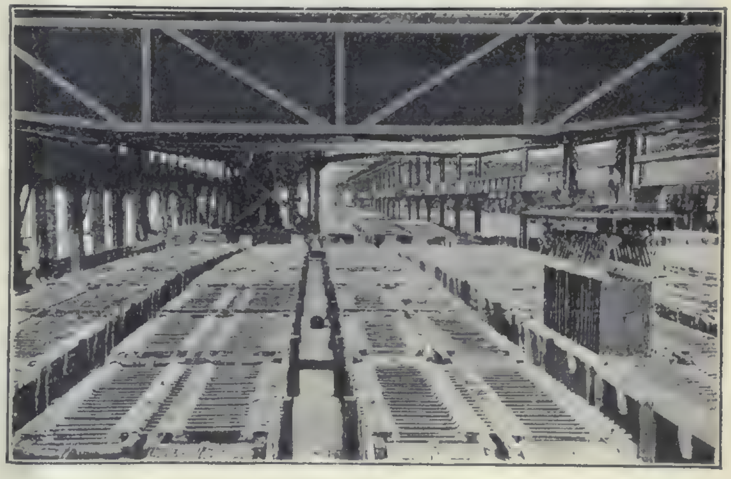
THE growth of the electrolytic copper refining industry during the last twenty years has been a notable illustration of the advantages of the use of electricity for separating small amounts of impurity from a metal that is widely used in the arts and industries. The demand for copper of exceptional purity for electrical construction work, which arose in the early eighties and has continued in ever increasing volume down to the present date, led to the rapid development of the electrolytic refining industry, and this method of purifying copper, first started upon an industrial scale by James Elkington[1] at Pembrey in South Wales, in the year 1869, has now become the most important of all the electrometallurgical industries, both in magnitude and in value of the finished product.

The advent of aluminium as a commercial metal, so far from diminishing the demand for copper, seems only to have stimulated it, and in 1911 the world's production of the red metal amounted to the stupendous total of 873,460 tons, of which it is estimated that quite 60% (or 523,800 tons) was refined by the electrolytic method. The value of this copper, at the average price for 1911 of £56 per ton, was £48,888,000. At the present rate of progress it is probable that in the year 1915 the world's output of copper will have risen to 1,000,000 tons per annum, and that the larger portion of this total will be required for electrical purposes, and will therefore have been passed through the vats of the electrolytic refineries.

The general principles of the electrolytic copper refining process are doubtless known to the majority of readers of the CHEMICAL WORLD, and a very brief summary of these will suffice to explain the process.

When an electric current of suitable strength is passed through a slightly acid solution of copper sulphate, using pure copper electrodes, copper is dissolved at the anode, and is deposited at the cathode in equal amounts. If raw copper, as for instance that known in the smelting industry as "Blister" or "Converter" copper, be substituted for the pure metal as anode material, the same action occurs, but in this case only the copper is deposited in the metallic form, and the impurities collect in solution and in the "slimes" or sludge at the bottom of the vats. As the chief impurities of raw copper are antimony, silver and gold, we have the noteworthy fact that the value of the recovered "impurities" in the majority of instances more than covers the cost of the purification process, and consequently that copper of 99·9% purity is in many cases cheaper than the Blister copper from which it is made.

Only a small E.M.F. of about ·12 volt is required to carry out the refining process, since the E.M.F. produced by the solution of copper at the anode nearly balances that required to deposit it at the cathode. The chief items of the running costs of the electrolytic copper refining process are consequently (1) interest on the copper stored in the vats, (2) repairs and depreciation of the very extensive depositing plant required, and (3) labour charges; while electric power is a comparatively small item of the total refining costs. There are now between thirty-six and forty refineries in operation, located in all the copper-mining countries of the world.



THE TANK HOUSE AT THE RARITAN COPPER REFINERY AT PERTH, AMBOY.

The largest refinery is that of the United Metals Selling Company at Perth, Amboy, New Jersey; and the most recent that erected at Port Kembla in New South Wales by the Mount Morgan and other Copper Mining Companies in the Australian continent.

The growth of the industry and the increase in the size of the refineries can be best illustrated by describing the equipment of the original Refinery at Pembrey in South Wales in 1869, and by comparing it with that of three recently-built refineries, namely, the Raritan Copper Works at Perth, Amboy, U.S.A.; the Port Kembla Refinery, sixty miles south of Sydney; and that of the Great Cobar Syndicate at Lithgow, near Bathurst, N. S. Wales. The descriptions are drawn from various sources, referred to in the footnotes to this article.

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[1] The first patent covering Electrolytic copper refining was taken out by Charles Watt in 1857; (Patent No. 13,755). Elkington's first Patent was dated 1865.

1. *The original Electrolytic Copper Refinery at Pembrey, near Swansea, was erected from the plans of Mr. James Elkington*, one of the founders of the famous Birmingham firm of electro-platers. The refinery was first put into operation in the year 1869. Full details of the plant and of the procedure adopted are given in the two Patents Nos. 2838 and 3120, granted to James Elkington in the years 1865 and 1869 respectively.

THE TANK HOUSE AT MESSRS. BOLTON'S WIDNES REFINERY.

Elkington employed cylindrical earthenware vessels 33 ins. high and 17 ins. in diameter, placed terrace-wise, as his electrolytic vats. Each vessel contained six cathodes and five anodes—each anode being faced by two cathodes. The electrolyte—a saturated solution of copper sulphate—was conveyed through the series by gravity, and was then pumped back to the highest vessel.[2]

One hundred of these vessels were worked in series, and the electrolyte was conveyed from the overflow of one to the bottom of the next by lead pipes. It is noteworthy that in all essentials this arrangement of plant is still followed to-day, and the following extract from Ulke's monograph[3] is of value upon this point:—

"The works established by the father of modern copper refining are in successful operation to-day, due chiefly to the remarkable fact that both Elkington's apparatus and process were well conceived, and needed but little improvement to bring them up to present standards."

The Pembrey Works have been much enlarged since these early days of the industry, when the output was only 15 cwts. per day of 24 hours, and the earthenware pots have given place to lead-lined vats of much larger cubical capacity.

According to Ulke, the total power now utilised at this plant is 385 k.w. The number of vats is 1,065, and anodes 24 ins. long by 10 ins. wide are employed, with cathodes 24 ins. by 4 ins. The E.M.F. per vat is ·30 volt. The Pembrey Works are no longer owned by the Elkington Brothers, but have passed into the possession of Elliot's Metal Co. of Swansea and Birmingham. The original output of 15 cwts. per day had been increased to 20 tons weekly (1,000 tons per annum) when the works were transferred to Elliot's Metal Co. According to Ulke, the present output is about 130 tons per week, or 6,500 tons per annum.

2. *The Raritan Copper Works, Perth, Amboy, New Jersey, U.S.A.*—This refinery is owned by the United Metals Selling Co., and is now the largest of the American refineries, and in fact in the world. Five 600 k.w. generators supply the current for the electrolytic vats, of which there are 1,600. The vat house possesses a floor space of 120,000 sq. ft., and the 1,600 vats are arranged in this house in four parallel rows of 400 each. Each vat measures 8 ft. in length by 2 ft. wide by 2 ft. deep, and contains when fully charged 22 anodes and 23 cathodes. Four travelling cranes run the full length of the building, over each row of 400 vats, and these cranes remove the complete sets of cathodes and anodes in one operation, when any group of vats is cut off from the electrolytic circuit for cleaning and recharging. *The daily* output of this refinery is between 150 and 200 tons (or nearly equal to the

WALKER AND THUM'S ANODE CASTING MACHINE AT THE BALBACH REFINERY, NEWARK, U.S.A.

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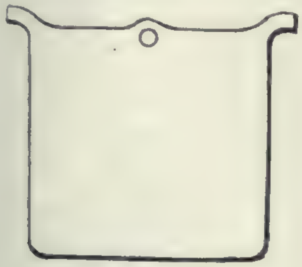
[2] "Electrometallurgy" by John B. C. Kershaw.

[3] "Modern Electrolytic Copper Refining," by T. Ulke.

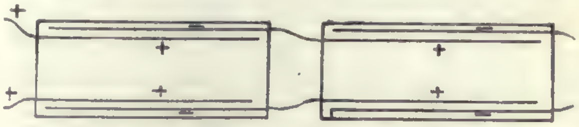
first year's production of the Pembrey refinery), and from 8,000 to 10,000 ozs. of silver and 175 to 200 ozs. of gold are recovered *daily* from the "slimes" collected in the vats. Very full details of the plant at this refinery will be found in the book by Ulke already referred to. The first illustration shows an interior view of the tank-house with a charge of anodes suspended from the overhead crane, ready for lowering into one of the vats on the right.

3. *The Port Kembla Refinery, New South Wales.*—This refinery has been erected in order to avoid the shipment of the raw copper mined in Australia to Europe or America for the final smelting and refining processes. The refinery has cost £137,000 and its erection has been financed by a group of copper and gold mining companies, of which the Mt. Morgan Co. is the chief member. The plant comprises reverberatory furnaces, converters for blowing the metal obtained from the smelting operations, and the electrolytic refining department. The latter is equipped with 366 refining vats contained in one large tank-house, served by travelling cranes—the method of work is very similar to that employed in the American refineries. The starting sheets are deposited on rolled copper plates coated with a mixture of oil, black grease and kerosene, or with tallow and graphite. In stripping the cathodes, care is exercised to withdraw a uniform quantity from the tanks daily, proportionate to the theoretical quantity which should be deposited; the Australian custom is to withdraw from 90 to 95% of this theoretical amount. The anode scrap amounts to from 10 to 15% of the anodes loaded, and a 90% current efficiency is obtained. No figures are available for the output of this refinery, but judging from the number and capacity of the vats it should be about 40 tons per day.[4]

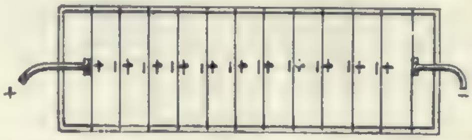

FORM OF ANODE SHEET.

4. *The Lithgow Refinery, on the Cox River, near Bathurst, N.S.W.*, is the oldest of the Australian refineries, and was erected by the Great Cobar Syndicate in 1901-2. G. H. Blakemore, in a paper read before the Institute of Australian Mining Engineers in 1910, has given a very full description of the plant at this refinery, and from this paper the following details are taken.

The power is supplied by 6 tandem steam-engines, each of 100 H.P.; these drive by belt transmission 6 four-pole shunt-wound dynamos delivering 1,200 amperes at 60 volts, when running at 350 r.p.m. The dynamos provide current for 672 vats, divided into three groups of 96 vats, and three of 128 vats; the maximum capacity of the whole dynamo plant is, however, equivalent to 864 vats. Each vat contains when fully charged 9 anodes and 17 cathodes. The vats are constructed of Oregon pine dipped in boiling paraffin wax, and are lined with 6-lb. lead. The fall between each tank is 3 ins.; the electrolyte flows from one vat to the other in cascade fashion. The pipes between the vats are constructed with rubber and glass connections, in order to avoid short circuits and current leakage. At each eighth tank the electrolyte flows into a sump-launder, which returns the liquor to the collecting tanks, from which it is pumped up to the sand filters by compressed air. The flow of electrolyte to the leading tank in each series of eight is, approximately, $1\frac{1}{2}$ galls. per minute. The sand filter removes the slimes carried in suspension in the liquors. This slime contains 0·023 grain of gold and 0·159 grain of silver per gallon. The tank-liquor is heated to 120° to 130° F. by means of hard-lead steam coils placed in the supply tanks and heated by waste steam. At this temperature the voltage drop per vat is 0·40 volt, and the capacity of the plant is between 150 and 200 tons refined copper per week. The liquor in each vat is separately agitated and circulated by a jet of compressed air, led to the bottom of the vat by a $\frac{1}{4}$-in. diameter composition gas-pipe, which discharges into a $\frac{3}{8}$-in. lead pipe. The expansion of the air lifts the liquor as in a Pohle air-lift, and both aerates the electrolyte and mixes it. The electrolyte contains 12 to 13% of free acid, has a specific gravity of 1·18, and is employed with a current of 12 to 14 amperes per sq. ft. The following are the points which the author emphasises as the secrets of success in electrolytic copper refining: (1) Efficient insulation; (2) cleanliness of all electrical connections; (3) a high temperature of the electrolyte; (4) correct composition and acidity of the electrolyte; (5) correct current density. The system of tank arrangement at the Lithgow plant is that known as the "multiple." The slimes are taken from the tanks at regular intervals. The percentage of scrap collected from the slimes in this way is about $8\frac{1}{2}$ to $9\frac{1}{2}$ % of the total weight of anodes treated, as compared with 12 to 15 % in the American refineries.



THE THOFERN OR PARALLEL SYSTEM OF ELECTRODES.



THE HAYDEN OR SERIES SYSTEM OF ELECTRODES.

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[4] *Electrometallurgical and Chemical Engineering*, July, 1910.

The author expresses his thanks to Messrs. Constable & Company for the use of the above illustrations.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By Emil Hatschek.

CHAPTER VIII.—*continued.*

An excess of about $5\frac{1}{2}\%$ of alcohol is found in the froth, which result again confirms our reasoning.

We have thus some direct evidence to support the view that the changes of concentration, classed together as adsorption, on a surface are due to the tendency of the surface energy to attain a minimum value, and that they occur if an *increased concentration leads to a reduced surface tension.* Our whole knowledge of the matter, however, is not based exclusively on such reasoning, which, as far as the solid surface is concerned, rests on the uncertain ground of analogy, but the principal proposition has been proved by thermodynamical methods by Willard Gibbs. He arrived at the following famous formula:—

$$U = -\frac{C}{RT}\frac{d\sigma}{dC}$$

in which the symbols mean:

U excess of substance in surface layer
C concentration in bulk of liquid
σ surface tension
R the gas constant
T the absolute temperature.

The formula contains the differential coefficient of the function connecting surface tension and concentration, which is, of course, positive if both change in the same sense, and negative if they change in opposite senses. This, in conjunction with the minus sign on the right hand of the equation, shows at once that there will be a negative excess, *i.e.*, a diminished concentration in the surface, if the surface tension *increases* with increasing concentration, and a positive excess, *i.e.*, increased concentration in the surface, if the surface tension *decreases* with increasing concentration. The latter is the more common case, and confirms the results previously arrived at; the former, however, has also been experimentally observed, and is known as *negative adsorption.*

CHAPTER IX.

Further conclusions can be drawn from the formula. As the absolute temperature appears in the denominator, the excess in the surface, or, in other words, the amount adsorbed—whether positive or negative—varies inversely with the temperature, and decreases as the latter rises, a point which deserves attention in some of the technical applications of adsorption. It also follows that a *small* amount of dissolved substance can *lower the surface tension greatly*, but can only *increase it slightly.*

When more than one substance is present in a solution, the process becomes necessarily complicated, but one or two points may be discussed briefly. It is quite possible that the various substances may not be adsorbed to the same extent, in which case one or the other may be removed selectively, as, *e.g.*, the colouring matter from sugar solutions. Where a single compound is dissolved in a dissociating solvent, the ions may likewise not be adsorbed equally, and the solution, originally neutral, may be acid or alkaline after adsorption; this also has been found to be the case, for instance, in Van Bemmelen's experiments on the adsorption of potassium sulphate by gels, when the remaining solution was found acid, *i.e.*, the $K^{\cdot}$ ion was adsorbed to a greater extent than the SO_4^{1} ion.

Although the formula does not include this term, it is obvious that the amount adsorbed, other things being equal, is proportional to the active surface—all substances, indeed, which are employed as adsorbents have very large surfaces. Charcoal retains the cellular structure of the raw material; kieselguhr consists of very fine and extremely complicated silicious skeletons of diatoms, while the gels, as we know, also possess a network or cellular structure with enormous surface. A material which has recently come into some prominence, especially through the work of Wislicenus, is the substance called in German "gewachsene Tonerde," *i.e.*, "grown alumina." This is an aluminium hydroxide, obtained by the oxidation of aluminium in presence of moisture and of extremely small quantities of mercury. It has a typical gel structure, and that its adsorbent effect is due to the latter is shown by the action remaining unaltered when the substance is dehydrated at red heat.

While we have thus a number of qualitative data regarding the phenomenon, one question is still open: whether it proceeds to any definite end point or equilibrium, and, if so, in what terms this can be expressed mathematically. These points are now settled by an enormous amount of material collected by various observers. One of the first experiments dealing with this problem was made by Wilhelm Ostwald, who placed a quantity of charcoal in dilute hydrochloric acid, and after a certain time determined the concentration of the latter. If then a portion of either the charcoal or of the acid was removed, no further change took place, which tends to show that an equilibrium between the concentrations—on the surface and in the bulk of the acid—has been attained. Further decisive experiments are due to Freundlich, who placed charcoal in solutions of acetic and of benzoic acids of known strengths and determined the amount adsorbed. The same amounts of charcoal were then placed into half the volumes of acid of double the strength used in the first experiments, and after a time an equal volume of solvent was added, bringing the total volumes to those used in the first instance. If there is a definite equilibrium between the adsorbed quantities and the end concentrations, the final concentration in the second experiment should be the same as in the first, and Freundlich in fact found this to be the case.

Mathematical investigation confirmed by an enormous amount of experimental work with a variety of adsorbents, solvents, and dissolved substances has established a definite relation between the quantity of adsorbent m, the quantity adsorbed y, and the end or equilibrium concentration c in the liquid after adsorption, which takes the following form:—

$$\frac{y}{m} = ac^{\frac{1}{n}}$$

in which a and n are constants depending on the nature of the solutions and the adsorbent. The curve corresponding to the above equation is known as the "adsorption isotherm," and it is obvious that it is a parabolic curve; for $n = 2$, it actually becomes the ordinary conic parabola.

It may be pointed out here that the formula is very frequently, but quite erroneously, spoken of as an "exponential" one. An exponential expression is one containing one of the variables—in the present case these are y and c—as exponent, whereas the exponent in the equation of the adsorption isotherm is a constant. It is an interesting fact that this constant varies within comparatively narrow limits for the most widely different substances, viz., roughly speaking, between $n = 2$ and $n = 10$.

The principal deduction from the equation is obvious: the amount adsorbed, other things being constant, increases much more slowly than the concentration of the solution. This becomes quite clear by choosing a simple example in figures, say $n = 2$, and m and $a = 1$ (a simplification always admissible in any one series of experiments). In this case

$$y = c^{\frac{1}{2}}, \text{ or, in a more familiar form, } y = \sqrt{c}.$$

If we therefore take c, the end or equilibrium concentration successively equal to 1, 4, 9, 16, we find the adsorbed amounts to be the square roots of these numbers, *i.e.*, 1, 2, 3, 4. This means that, if double or treble the amount of substance is to be adsorbed, the remaining solution must be four or nine times as concentrated as for unit adsorption. As the initial concentration of each solution, before adsorption, is evidently $y + c$, we find that the initial concentrations corresponding to the adsorbed amounts chosen must be 2, 6, 12 and 20. Accordingly, in the example chosen, the initial concentration must be increased ten times if the adsorbed amount is to be four times as great.

The adsorption isotherms and the exponents $\frac{1}{n}$ have been determined for many substances and solvents. The table below shows a number of determinations by Freundlich.

Adsorbent.	Solvent.	Substance Dissolved.	$\frac{1}{n}$
Blood charcoal ..	Water	Formic acid ..	0·451
,, ,, ..	,,	Acetic acid ..	0·425
,, ,, ..	,,	Benzoic acid ..	0·338
,, ,, ..	,,	Picric acid ..	0·240
,, ,, ..	,,	Chlorine ..	0·297
,, ,, ..	,,	Bromine ..	0·340
,, ,, ..	Benzol	Benzoic acid ..	0·416
,, ,, ..	,,	Picric acid ..	0·302
,, ,, ..	Water	Patent Blue ..	0·190
Wool	,,	Patent Blue ..	0·159
Silk	,,	Patent Blue ..	0·163

The table shows clearly the limits between which the exponent varies, and a further point of interest is raised by the behaviour of the same solution—Patent Blue in water—towards three adsorbents as different as charcoal, wool, and silk. The value of the exponent does not differ greatly in the three cases, and it has been very generally observed that the influence of the adsorbent is very slight compared with that of the other factors. Various adsorbents have been investigated, but no quantitative relation has been established, and the difficulty of doing so becomes obvious when we remember that we have no means of determining and comparing the active surfaces of substances like charcoal and fibres. It is, however, fairly well established that the *order* in which various dissolved substances are adsorbed is the same for different adsorbents; if a substance A is more strongly adsorbed than another B, and the latter more than C, by charcoal, the same order will hold good for other adsorbing materials, although the numerical ratios may be altered.

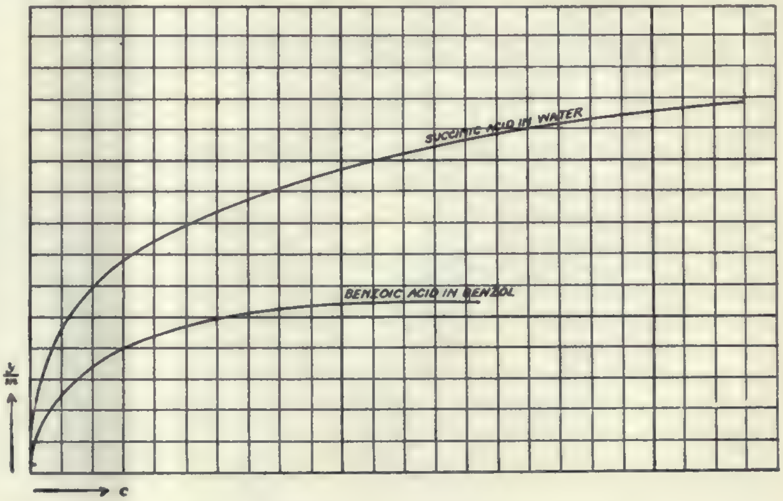


FIG. 13.—TYPICAL ADSORPTION ISOTHERMS.

Another question of importance has not been touched on so far, that is the effect of the solvent, in all cases where a substance is soluble in more than one liquid. It is well known, even from general experience, that this same substance is not adsorbed equally out of solutions in different solvents, and that adsorption is much slighter in organic solvents than in water. Thus Freundlich gives the following figures for the adsorption of benzoic acid out of solutions of equal strength in :—

Water	3·27
Benzol	0·54
Ether	0·30
Acetone	0·3

This peculiarity of organic solvents is practically used for removing substances adsorbed out of aqueous solutions. A dilute aqueous solution of a dye, like crystal violet, can be completely decolourised by charcoal. If the latter is then placed in alcohol, the adsorption from which is much lower, the surface concentration of the dye on the charcoal is in excess of that which would establish equilibrium, and a large amount of it therefore goes into solution.

Two typical adsorption isotherms are shown in Fig. 13. They are also due to Freundlich, and strikingly illustrate the parabolic character of the curve.

(*To be continued.*)

PERSONAL AND OTHER NOTES.

Dr. G. T. Beilby, F.R.S., has been appointed a member of the Royal Commission on Oil Fuel in succession to the late Dr. H. Owen Jones.

Nature reports that a bequest of the late Mr. J. E. Taylor of £20,000 to the Victoria University, Manchester, has now become payable by the recent death of his widow.

It is announced in *The Morning Post* that the foundation stone of the Agricultural College for Devonshire will be laid in October, probably by Mr. Runciman, President of the Board of Agriculture. The College is being provided as the result of a bequest by the late Mr. Charles Seale Hayne, M.P. for Mid Devon, who left nearly £100,000 for the purpose; £20,000 will be spent on the buildings, and the balance will form a fund for administrative purposes. The site is the Howton Estate, covering more than two hundred acres, near Newton Abbot.

The following research scholarships in agricultural science have been awarded by the Board of Agriculture and Fisheries :—F. Cook, London (animal nutrition); F. C. Minett, London (animal pathology); F. Summers, London and Liverpool (plant physiology); A. W. Ashby, Oxford (economics and agriculture); J. Davidson, Liverpool (agricultural zoology); J. A. Prescott, Manchester (plant nutrition and soil problems); A. Cunningham, Edinburgh (bacteriology); A. E. Cameron, Aberdeen (agricultural zoology); P. A. Murphy, Dublin (plant pathology); M. S. Pease, Cambridge (genetics); W. Buddin, Cambridge (plant nutrition and soil problems); W. W. P. Pittom, Cambridge (animal nutrition). The scholarships, which are of the annual value of £150, and are tenable for three years, have been established in connection with the scheme for the promotion of scientific research in agriculture, for the purposes of which the Treasury has sanctioned a grant to the Board from the Development Fund.

Dr. J. K. Caird, jute manufacturer, Dundee, has given £10,000 to the British Association funds.

The Lord Lieutenant of Berkshire, Mr. J. Herbert Benyon, has given £5,000 towards the new buildings fund of University College, Reading.

The meeting of the British Association at Dundee was one of the most successful on record, the number of members attending being nearly 2,500. The sections dealing with chemistry, physics, engineering, agriculture, and mathematics were particularly fortunate in the attendance, and papers submitted. The opening address by Professor Senier, M.D., D.Sc., in the chemical section dealt at length with many sides of modern development.

At the annual general meeting of the Society of Chemical Industry, held in New York, Sir William Crookes, O.M., F.R.S., was awarded the Society's medal for his discoveries in physical chemistry and the rare metals.

Dr. W. N. Haworth has been appointed to a Lectureship in the University of St. Andrews, instituted in connection with the Chemical Research Laboratory of the United College.

International Association of Leather Trades Chemists.

A Conference was held in London on September 16th and following days, under the presidency of Dr. J. Gordon Parker, F.I.C. Mr. F. W. Reid, F.I.C., Past President of the Society of Chemical Industry; Mr. W. P. Dreaper, F.I.C., on behalf of the Institute of Chemistry, and Society of Dyers and Colourists; Mr. A. Chaston Chapman, F.I.C., President of the Institute of Brewing; and Mr. F. J. Lloyd, F.I.C., on behalf of the Agricultural Analysts' Association, extended a general welcome to the Foreign delegates.

The following papers were read and discussed :—

Report of the referee on acidity determination in liquors. Prof. H. R. Procter.
Report of the referees on control of lime liquors and wet work. J. T. Wood and Dr. J. G. Parker.
Report of the referees on the analysis of leather. Prof. B. Kohnstein and Urbain Thuau.
Notes on the behaviour of leather against light, estimated with Kallab's apparatus. Prof. Joh. Paessler.
Report of the referee on qualitative estimation of vegetable tannin extracts. Dr. Edmund Stiasny.
Report of the referee on analysis of tannins (including colour measurement). Prof. H. R. Procter.
The use of animalised cotton for examination of tanning solutions. Dr. A. Gansser.
The analysis of sulphited extracts.
Note on tannery effluents. Prof. Louis Meunier.
The soaking of hides and skins by means of organic acids. Dr. J. G. Parker.
The question of adulteration and weighing of leather. Dr. J. G. Parker.
Proposed appointment of referees on analysis of fish oils.
Salt stains on hides and skins. Prof. Joh. Paessler and Prof. Hch. Becker.
The action of alkaline carbonates in the formaldehyde tannage.—General observations on the tannage of skins. Prof. Louis Meunier.

THE FOOD PRODUCTS OF RHODESIA.

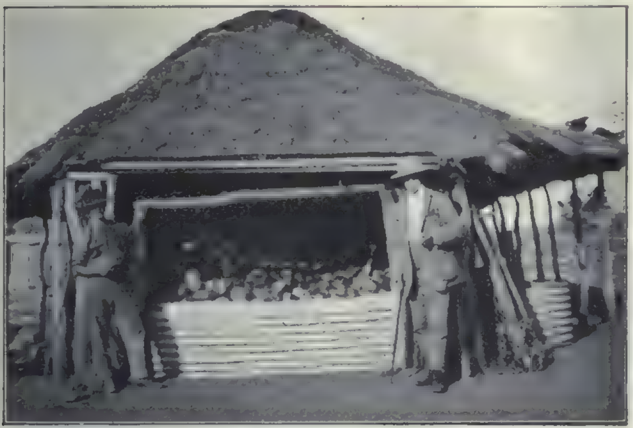
By Loudon M. Douglas, F.R.S.E.

(*Continued from page* 311.)

It will be observed in the preceding tables that the balance of the oil is made good by the use of monkey nuts.

No. 1 ration would be more suitable if fed along with silage or other green fodder, leaving out the leguminous plants, such as have an albuminoid ratio of 1 : 7 to 1 : 8, and the same remark may be made with regard to ration No. 2 for fattening bullocks. The bulky food is, of course, a prime consideration in the utilisation of any of these cereals, and in many districts can be well supplied from pumpkins and sweet potatoes, or from the sweet veld grasses.

The feeding of cattle is becoming a very serious problem in Rhodesia, as it is generally admitted that the future of the agriculture of the country will largely consist of the development of an export meat trade, and, with this end in view, dairying and ranching are being largely extended, and it is hoped that within a very short period a sufficient supply of cattle will be available to maintain packing houses on the spot. Under normal conditions, such a state of things should be possible within four or five years, but it will require the united efforts of the farmers to make the scheme a success.



A Store of Kaffir Melons and Pumpkins for feeding Live Stock.

Pig Feeding.—The immediate question in Rhodesia is the feeding of pigs, and the food which has been grown is to a considerable extent being used in swine husbandry. For this reason, therefore, it may be desirable to more particularly examine the technical part of the feeding problem, in so far as pigs are concerned.

In England, Denmark and elsewhere, the ration which produces the best results in fattening pigs for the bacon factory is a mixture of barley meal and separated milk in varying proportions, and as the value of a food, assuming its digestible and palatable qualities, can be best measured by the protein it contains in relation to the carbohydrates and fat, it is of interest to compare the "wideness" of the above-mentioned ration with that of the feeds available in Rhodesia.

Feeding barley has the following composition in round figures:—

Protein	12%
Fat	2½%
Carbohydrates	58%

Multiplying the fat in the usual way by 2½ and adding the product to the carbohydrates we obtain in round numbers:—

Protein, 12; Carbohydrates, 64; or a ratio of 1 : 5⅓.

Separated Milk contains:—

Protein	4
Fat	¼
Carbohydrates	4¾
	9

Working out as above, this gives a ratio of 1 : 1⅓.

The amount of separated milk in the ration usually varies between 2½ and 4 parts of milk to 1 part of barley. Let us take the average as follows:—

Barley	1 part
Separated Milk	3 parts.

The ration works out as follows:—

	Protein.	Fat.	Carbohydrates.
1 Barley ..	12% = 12	2½% = 2·5	58 = 58
3 Separated Milk ..	4% = 12	¼% = ·75	4¾ = 14¼
	24	3·25 × 2½	72¼

= 8 + 72¼

= 24 : 80¼

or 1 : 3⅓

This is quite a narrow ration and shows that for the best results a large proportion of protein in the food is necessary.

We will now compare this ration with the feeds available in Rhodesia.

The first item is, naturally, maize, and, as the different varieties of this grain do not differ very much in composition, we will assume an average analysis as follows:—

Protein	11½%
Fat	3½%
Carbohydrates	71¾%

giving the ratio 1 : 7, which is much too wide for the best results, and we must try to find some other feeding stuff to blend with it to bring up the proportion of protein, keeping in mind that it is desirable in Rhodesia to feed as large a proportion of maize as possible to the pigs. We must therefore look for some foodstuff with the highest percentage of protein to blend with it. Peas and beans we reject, as too large a proportion of them would be needed to effect the desired result. Monkey nuts contain too much oil, but as the oil is a valuable article of commerce, the manufacture of which is being considered in Rhodesia, it is probable that monkey-nut cake may, before long, be available.

Nyasa "Boys" or Natives from the Northern Territories shelling Mealies on a Rhodesian Farm.

The analysis of monkey nuts gives the following figures :—

Protein	29%
Fat	44%
Carbohydrates	14%..

Ratio 1 : 4¼.

The nuts therefore would not help us in bringing up maize to the proper ratio. Let us, however, try to work out the composition of monkey-nut cake. On the average, by the expression process the residual cake would contain, say, 7 to 8% of oil. Assuming 7½% as a fair figure, this means that 40 of the 44% of the oil in the nuts would be expressed, the residue would then have the following composition :—

Protein	54½%
Oil	7½%
Carbohydrates..	26½%

Ratio 1 : 0·83.

A very high concentration of protein indeed and one that will enable us to bring up the ratio of maize in the best possible way, as the following calculation shows :—

	Protein.	Fat.	Carbohydrates.
5 Maize	11½ = 57·5	3½ = 17·5	71¾ = 358¾
1 Monkey-nut cake	54½ = 54·5	7·5 = 7·5	26½ = 26½
	112	25 × 2½	385¼

Ratio 1 : 4.

This is a little wider than the separated milk and barley ration, but would probably be found narrow enough for average fattening purposes. Where an extra ration is required, the following might be adopted :—

4 Maize.
1 Monkey-nut cake.
Ratio 1 : 3½.

Monkey nuts are very palatable to pigs, and no doubt the cake would be equally so. Very probably the deterioration which has been noted in pigs bred in Rhodesia is due to the difficulty of getting feed with sufficient protein in it, and it seems certain that if monkey nut cake could be had in abundance at a fair price it would solve the difficulty. If possible, the cake and maize should be ground to fine meals and fed as thin slop.

Turning to the question of green stuff for the ordinary and filling up ration, the standard of comparison is naturally grass, the analysis of which, as pasture, is as follows :—

Protein	3½%
Fat	¾%
Carbohydrates	10 %

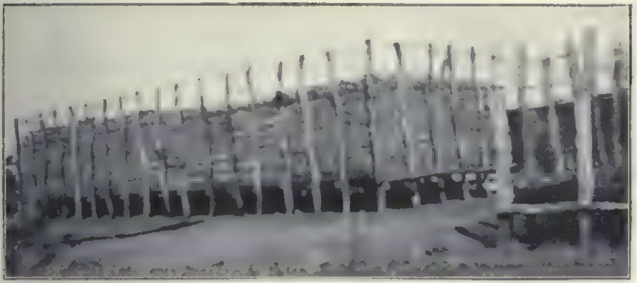
Ratio 1 : 3⅓,

or exactly the same as the barley meal and separated milk ration. If grass were abundant in Rhodesia, no other green stuff would be necessary, but as it is scarce and only available for a short season, it is necessary to inquire into the other green stuffs to be had. Pumpkins are abundant, but have very little feeding value; containing as they do, however, about 90% of water, they supply the fluid necessary. The ratio of the food constituents is very wide, at least 1 : 12.

Green maize and maize straw are, of course, abundant. A very good mixed feed is produced by sowing fresh rows of maize between those of the regular crop when the latter is half grown. The catch crop will be half grown and succulent when the standard one is ripe, and both can be cut and fed together, making an excellent mixture.

The composition of green maize and maize straws are as follows :—

	Green Maize.	Maize Straw.
Protein	.. 1½% ..	5%
Fat	.. ½% ..	1½%
Carbohydrates	.. 9½% ..	34½%
Ratio	1 : 7 ..	1 : 7½



Mealie Bin on a Rhodesian Farm.

The ratio is very similar in each case, but the protein is much too low for satisfactory results. To help this, almost any kind of pease or beans should be fed along with the green maize, maize straw, and pumpkins. Take native beans as an example.

Analysis in round figures :—

Protein	20 %
Fat	3½ %
Carbohydrates..	57½ %

Green Maize Ration.

	Protein.	Fat.	Carbohydrates.
4 Green maize	1½ = 6	½ = 2	9½ = 38
1 Native beans	20 = 20	3½ = 3½	57½ = 57½
	26	5½ × 2½	95½

working out at 1 to 4⅓ which would serve as a non-fattening ration. In the fattening period the proportion might be made 3 of green maize to 1 of beans.

Weighing Mealies on a Rhodesian Farm.

Maize Straw Ration.

	Protein.	Fat.	Carbohydrates.
1 Maize straw	5 = 5	1½ = 1½	34½ = 34½
1 Native beans	20 = 20	3½ = 3½	57½ = 57½
	25	5 × 2½	92

Ratio 1 : 4

Monkey-nut cake could, of course, be used instead of beans or pease to bring up the protein contents of the ration, and separated milk would be even better.

The foregoing examination makes it evident that there is a scarcity of protein in the principal foods available for pig feeding in Rhodesia, and it will be necessary to supplement these with more concentrated stuff right through the lifetime of the pig.

The establishment of bacon curing in Rhodesia has been decided upon as the first of these animal industries which are likely to play such an important part in the future of the country, and it may be said that at the present time there is every chance for this industry being conducted with great profit to agriculture, inasmuch as the imports of pig products into the country and into South Africa generally total up to something like a value of £400,000 per annum. Such a basis to work upon makes success in this undertaking pretty certain, and there is every chance therefore that by this means large profits may be made to accrue to the agriculture of the country generally.

DECOMPOSITION OF NITRIC OXIDE BY PRESSURE.

One of the most curious properties of Prof. Strutt's chemically active nitrogen is its action on nitric oxide ; this substance, instead of combining with the active nitrogen to form nitrous oxide

$$NO + N = N_2O,$$

is actually found to be oxidised in such a way that on cooling the gas blue crystals of nitrous anhydride are deposited. This abnormal action may be expressed by the equation

$$N + 2\,NO = NO_2 + N_2$$

or

$$N + 3\,NO = N_2O_3 + N_2.$$

It can be accounted for on the ground that the affinity of nitrogen for nitrogen is greater than that of nitrogen for oxygen, but gives quite a novel impression of the relative stability of the different oxides.

E. Briner and A. Wroczynski (in the Geneva Archives *32*, 389–414) show that if nitric oxide be condensed by liquid air and sealed in a glass tube, the colourless contents of the tube undergo a change, whereby on the following day one may recognise the formation of a blue-green vapour, and even of a small drop of blue-green liquid in those tubes in which the pressure is greatest. The decomposition occurred in a few hours when the pressure exceeded 250 atmospheres, and might depend on a simple dissociation

$$2\,NO \rightleftarrows N_2 + O_2.$$

This would be slightly hindered by compression but for the fact that the combination of the oxygen with nitric oxide results in a marked contraction ;

$$6\,NO \longrightarrow 2\,N_2\,O_3 + N_2$$

in which the volume is seen to become halved, even without allowing for polymerisation or condensation of the nitrous anhydride.—T. M. L.

NOTES ON CHEMICAL RESEARCH.

By The Editor.

CHAPTER VII.

General Conclusions.

> "I know not what the world may think of my labours, but to myself I seem to have been only like a boy playing on the seashore, and diverting himself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me."—*Newton.*

It is evident that the field of research is an ever-widening one. Each discovery is but a stepping-stone to others. Single observations may, as in the past, give rise to new sciences, called into existence to meet the new conditions, which have to be examined and recorded. As there is no finality to research, this condition will prevail equally in the future as in the past.

This natural development in the field of investigation is of great importance to the student. The increased tendency to sub-division, and the dividing up of science into a number of more or less water-tight compartments, for which there is obviously no counterpart in nature, is a defect which cannot be removed under present conditions. An examination of the results arrived at in one section, in comparison with those obtained in another, will hardly fail to indicate new lines for further investigation, and the young investigator should pay special attention to this point.

Knowledge is increased in this way. The application of the latest developments in colloidal chemistry to the theory and practice of dyeing, brewing, filtration, and the study of solutions and their properties, are examples of this class of work. The student need only remember the importance of this application to the theory of photographic emulsions to immediately appreciate this point.

In the different branches of physical chemistry this interdependence is equally obvious and necessary.

The student who is trained to realise the inwardness of things rather than to act as a mere recorder of endless phenomena, in terms of certain methods of expression, will recognise this position by choosing a direction for investigation which holds out a reasonable promise of success.

Use of Mathematics.—This examination, when it involves a mathematical treatment, is a source of inspiration to many, if it is a corresponding trial to others. The conditions of research have been so modified of late years, that it is almost impossible for the investigator to carry on his work in a satisfactory manner without a working knowledge of mathematics. This has not been sufficiently recognised in the past. The methods of teaching this subject have also been in many cases so academic, that the student has generally failed to appreciate the importance of its practical application.

The far-reaching effect of the application of mathematics to experimental science is obvious. It is impossible to consider certain branches of chemistry without it. Its extended use in the science of engineering, or in physics, will be a constant reminder to the chemist of its practical value.

The statement has been generally made, that from his method of thought, the chemist can never be a transcendental mathematician. This may or may not be so, but the general investigator has no such need before him. He must be content with a sufficient working knowledge of the practical side of mathematics. The worker who has not this knowledge may be referenced in the first instance to a Course of Practical Mathematics by Saxelby, or to Higher Mathematics for Chemical Students by Partington. Either of these will at once indicate that, within certain limits, the subject can be treated in a manner which is well within the grasp of any chemist, and also that one cannot fail to gain advantage from a working knowledge of this subject.

A certain want of understanding which exists between the workers in chemistry and physics may be to an extent due to the fact that they often, in the absence of a common use of mathematics, employ different methods to express results.

Methods of Recording Results.—Great importance should be attached to the registration of all references to the work in hand. Nothing is more annoying than the search for material, which is only generally remembered as being in print. This record should cover as extensive a field as possible, on both the theoretical and practical sides. All such references must be conveniently classified, preferably by card index, rather than by note-book system. They must be kept in a convenient form for future reference. In a few years this source of information becomes one of great value. A note-book for immediate use, and such a system of registration as some form of alphabetically-arranged record, or card index, is a necessary condition to systematic investigation.

It is essential that all observations, and any provisional conclusions based upon them, should be immediately registered. At certain stated intervals in the progress of the investigations these must be closely examined, notes written up, and the influence of any further results obtained on the direction of the research carefully observed, and any possible developments arising out of them considered. This procedure saves much time and secures a systematic registration of results. This is a matter of importance, and an absolutely necessary condition to systematic work.

It is interesting to note that Faraday, who is recognised as probably the most precise investigator of the nineteenth century, had (according to Tyndall), as his most prominent characteristic, a sense of order which "ran like a luminous beam through all the transactions of life." His notes on this subject were found, on examination, to be numbered, the last paragraph being registered as No. 16,041.

Publication of Results.—This subject raises considerations of great moment to the investigator. When research work is conducted to a successful issue in a college, or university, it is nearly always published. In other cases publication may defeat the whole object of the research unless, at the same time, protection by patent is obtained.

Publication may take place through the medium of the recognised societies, in which case the communication is submitted to the Secretary for consideration by the Publication Committee. One obvious advantage of this method is that the communication may be read before the members and discussed.

(*To be concluded.*)

INDUSTRIAL CASEIN.

By GEOFFREY MARTIN, Ph.D., M.Sc., B.Sc.

ALTHOUGH casein in the form of cheese has been used as a food from time immemorial, its utilisation for industrial purposes is a quite recent development. A short account of this new industry may, therefore, prove interesting, as little has been written upon the subject, and casein products of the greatest industrial value have within the last few years been placed upon the market.

The first firm to manufacture technical casein in Europe, and who performed most of the pioneering work in connection with this new industry, was a limited liability company known as "Casein Limited," founded by Mr. E. P. Carpenter. Owing to their patents, the large scale on which they work, and the highly skilled chemical control of the processes, this firm still leads the British Market, and also exports large quantities of casein abroad. The firm consumes about 30,000 gallons of skim milk daily in the summer months, representing about 4 tons of casein daily. Their factories are situated at Tipperary in Ireland.

The export of casein from the United Kingdom was £21,000 in 1910, and the import—principally from South America—was £50,000. The United States imported in 1910 about 1,700 tons of total value $304,000. In every case the main market is the home market.

The starting point of the industry is skim milk—formerly used for feeding pigs—which is milk from which the cream and fat has been machine-separated and used for butter-making. An average skim milk contains 3% casein, 0·4% milk albumin, 0·15% fat, 4·7% milk sugar, and 0·7% mineral matter. The casein is precipitated by various acids such as sulphuric, hydrochloric, acetic, lactic, and sulphurous (casein for different purposes is precipitated with different acids), washed, freed from traces of fat, and dried. The mother liquors and wash waters are worked for the milk sugar and milk albumin by partial neutralisation, followed by low temperature concentration *in vacuo* and crystallisation. The albumin may be separated by steaming, when it coagulates and separates on the surface of the sugar syrup. It is pressed to cakes and sold as a constituent of cattle foods. It is now more usually separated in a soluble form by a complicated and costly process and sold as a component for invalid foods under the names "Lactalbumin, Milk albumin," etc. The refined milk sugar fetches a very good price, being used for children's foods, and for adding to various beers and stouts. The sugar, not being fermentable by ordinary yeast, may be added to the wort and remains in the finished stout to increase its "extract value."

Casein is largely used for "sizing" paper. It is dissolved in alkaline solutions, and mixed into the paper pulp, when it forms an excellent binding agent for filling matter and pigments. The process is especially useful when the paper pulp has to be moulded or pressed into relief forms, as the casein size is very resistant to heat or moisture. When employed in certain special surfacing processes it produces extremely beautiful art papers. Some of the very best photographic papers are casein sized, the papers being extremely resistant to heat and moisture, and thus will keep in the tropics.

More usually the casein solution merely supplements ordinary engine sizing. The leather and textile industries also employ casein for "dressing" and "finishing" purposes.

Next in importance to its use as a "sizing agent" comes its use as a cold glue. Excellent glues are made merely by stirring up casein with distilled water and a little sodium bicarbonate, sometimes with the addition of shellac. In the woodworking trade casein glues threaten to displace ordinary gelatin glues because casein glues can be applied cold (so that all the trouble of melting the glue is avoided), can be made waterproof, and by their use certain delicate effects are attainable in veneering work which are impossible with gelatin glue, since the latter must be applied *hot*, and is not waterproof. Several American firms are now producing these glues in large quantities.

A great impetus to the casein industry has been given within the last few years by the remarkable discovery that when treated with certain chemicals casein is converted into extremely tough hard substances like bone or ivory, which can be kneaded and moulded when hot and when cold can be polished and worked. The best known of these products is *galalith*, which is made by treating casein with formaldehyde. It forms a tough white product, which can be coloured or marbled when hot by stirring in dyes, soot, etc. It is now used for making piano keys, backs of brushes, imitation ivory articles, and especially as an insulating medium for electrical fittings.

Being non-inflammable, it is used as a total or partial substitute for celluloid, but has the disadvantage that it cannot be produced in very thin transparent sheets.

Similar substances are produced by adding to a caustic soda solution of casein various chemicals such as sulphur, water glass, lime, sand, zinc and lead hydroxides, wood meal, cork dust, and so on. Such compositions are used for producing mouldings for picture frames, friezes, fancy articles, and toys. It will be remembered that plumbers have for years used a cement of red or white lead and cheese.

Attempts have even been made to produce artificial silk fibres from casein, either alone or mixed with other products, and much secret research is going on with this object.

Another development of the casein industry is its use in the manufacture of paints. It has long been known that the addition of casein to limewashes increases their durability owing to the casein combining with the lime to form agglutinant compounds, which harden in the air to an insoluble cement. Many of the "Washable Distempers" now on the market have casein glue as a base. In the United States an extensive sale of "Casein Paints" takes place—these paints consisting of casein powder mixed with lime and colouring matters, and are sold in closed tins. They are very cheap and stable, but the lids of the tins must be kept on, otherwise the paint spoils. These paints have now a considerable sale in this country.

Casein is now being used for fining wines, since it has the advantage over gelatine that it is completely precipitated by the natural acidity of the wines, nothing remaining as a contaminating agent. A considerable export trade to wine-growing countries is now done.

It is also used as a constituent of boot polishes, leather polishes, etc.

Last, but not least, a few words must be said on casein foods. Although a much smaller amount is consumed in their manufacture than in some of the technical applications above described, yet the trade is an important and growing one.

The great medicinal value of casein arises from its high phosphorus and nitrogen content ($P = 0{\cdot}8\ N = 15{\cdot}7$), so that when mixed with milk albumin, lecithin (a compound of choline, $CH_2OH\ .\ CH_2N(CH_3)_2OH$, glycerol, phosphoric and various fatty acids, which is made technically from yolk of eggs, and absorbed in wheat protein), alkaline salts of glycerol, phosphoric acid, $C_3H_5(OH)_2O\ .\ PO(OH)_2$, as well as iron organic salts, a variety of nitrogenous phosphorus-rich and mineral-rich brain and nerve foods are produced, which act in a most remarkable way in certain nervous disorders. Very many of these foods are now on the market, the most recent, and perhaps the most successful, being "Visem." Other well known brain foods of this nature are Sanatogen and Plasmon.

Technical casein furnishes a striking example of an industry generated by the research chemist from a practically valueless by-product—skim milk—a large proportion of which found its way into the "sewers."

PLATINUM.

PLATINUM was first discovered in 1784 and for nearly 90 years its value was considerably less than that of gold; in many of its properties it surpasses gold, and for many purposes it is preferred to it. The main supply for the world's consumption has come from Russia, and in order to make the price as firm as possible in that country during the reign of Nicholas I., platinum coins were struck of 3, 6 and 12 roubles, consisting respectively of 0·3355 oz., 0·6710 oz., 1·342 ozs. According to the ordinary value a platinum coin of 12 roubles is the equivalent of £1 5*s.* 6*d.*; but the weight of the metal at recent prices would be worth £5 13*s.* 7*d.* The quantity of metal used for these coins reached 473,147 ozs. Its use for coinage ceased as the output of platinum increased and the value of the metal fell, which led to the illegal coinage of platinum money containing the regulation quantity of platinum. At a more recent period the platinum industry made considerable progress, and it was put to a great variety of uses as it was cheaper than gold and it was, through its qualities, a complete substitute; moreover, it had many qualities which gold had not. These qualities have made it indispensable in the arts and manufactures, and the demand has outgrown the supply, as is shown by the following price fluctuations during recent decades :—

PLATINUM AVERAGE PRICES.

	Per oz.				Per oz.		
	£	*s.*	*d.*		£	*s.*	d.
1890.	1	15	8	1910. January..	6	7	0
1895.	2	2	0	1910. June ..	6	17	6
1900.	3	19	9	1911. January..	8	6	8
1905.	4	10	4	1911. June ..	9	1	3
1906. October	7	19	8	1912. January..	9	16	0
1908. Summer	4	5	0	1912. June ..	9	11	0

Early in 1911 the price of platinum reached the highest level it had ever attained; the metal sold in Maiden Lane at £8 15*s.* 7*d.* per oz. for the hard variety, and £7 17*s.* 3*d.* for soft platinum. The previous high record was in December, 1906, when the corresponding quotations were £8 3*s.* 4*d.* and £7 15*s.* 0*d.* The increase of price is due to the growing demand for the metal, combined with the diminishing ore reserves, and the increased cost of mining the placers in the Russian Urals, which constitute the chief source of supply. Early last year there was on foot a proposed federalisation of the Russian platinum placer deposits and federal supervision of the exports of the metal. This has given an impetus to the search for other sources of supply, especially in Colombia, which was formerly the world's leading producer, and where platinum was originally discovered. The platinum produced in the United States from the sources described in detail below is relatively insignificant in amount, and is derived as a by-product from working gold placers, chiefly in Oregon and California.

The Russian output during recent years may be summarised as follows: During 1910 the production of platinum in the Urals reached 175,716 ozs. according to official figures, which were obtained in placers in the respective mining districts as follows: Tcherdyn, 6,352 ozs.; Perm, 46,022 ozs.; South Verchotur, 110,800 ozs.; North Verchotur, 11,575 ozs.; South Ekaterinberg, 965 ozs.; North Ekaterinberg, 2 ozs. The output for 1909 was 164,118 ozs., and for 1908 156,192 ozs. The results of recent years indicate that the deposits of Tcherdyn, North Verchotur, and South Ekaterinberg are gradually becoming poorer; whilst Perm and South Verchotur have increased their yield. The great rise in the price of platinum has resulted in renewed efforts to develop the poor placers, which, in previous years of low prices, were not worked at all. To the above figures quite 60 % should be added for platinum surreptitiously produced, which reaches the market through other than the official channels. During 1911 the exports of platinum ores from Russia amounted to 6,871 kgms.

For comparison the quantities from 1902 are given below :—

1902	..	6·127 kgms.	1907	..	5·379 kgms.
1903	..	6·010 ,,	1908	..	4·876 ,,
1904	..	5·031 ,,	1909	..	5·112 ,,
1905	..	5·257 ,,	1910	..	5·473 ,,
1906	..	5·770 ,,			

The subject is discussed more in detail below.

It is generally assumed that the rich Russian placers from which the platinum is derived are related to Dunite, a variety of Olivine, which occurs in the Urals over a somewhat narrow zone, where the original rock has been developed. The placers occur along the slope of the mountains and in the rivers flowing from them. Although, during recent years, there has been an increase of production, there is said to be a decline in the average yield, which is now only 0·07 oz. of crude platinum per ton of gravel, excepting very occasional richer pockets. Formerly, better results were obtained. Now the platinum operators have to work deposits that are poorer, or, if they contain a higher content of the metal, they occur in more remote or difficult districts, or they may be at greater depths, or subject to other difficulties. So long as the recent high prices continue these deposits can be worked at a profit. Recent prospecting has shown that in the chief platinum region, the River Ussa, new platinum placers are not likely to be discovered. The Tagilsk region has been worked for 75 years and unknown deposits are not likely to occur. The stretch of the olivine in the Northern Urals, in areas not only uninvestigated, but hardly even visited by man, can alone offer hopes of new discoveries of rich platinum districts.

The Russian ore is not pure platinum, but is an alloy of six metals of the platinum group. In addition, the crude ore contains some gold, which can be separated by amalgamation ; also iron, magnetic iron and chromite. The separation is effected chemically, the bulk of the ore is sent abroad ; in Petersburg there are two factories for treating it, but the quantity worked upon is small, amounting to only 200 kgms., a year, a very small proportion of the output. The work is mainly done by German, French, and English firms. America covers most of her large platinum demand by purchase of the pure metal from Europe, although some crude American platinum is also worked up, obtained from localities described below. The separation of the platinum metals from the accompanying minerals is quite simple ; but the exact separation from one another of the individual metals of the platinum group forms one of the most difficult tasks of chemistry.

It is frequently important that exact separations should be made, for even small admixtures of others may strongly affect the technically important qualities of the entirely pure platinum metal desired ; thus, a small content of iridium makes platinum considerably harder. The first task is to separate the most important metal, platinum, and then to separate from each other the other five metals, as important uses have been found for each. As they are present in the ore only in small quantities, their value is even greater than that of platinum. Notwithstanding the great rise of price, being twice as great as the rise in price of platinum in 1908, in consequence of which it is possible to work mines with an output twice as little, there has not been a very great increase in the production of the metal. That shows that the Ural platinum deposits are, to a large extent, worked out, and that new ones to take their place have not yet been discovered. The effect of this situation is to cause some authorities in the Urals to say that there is no reason to hurry in working the metal out, considering that the price, in consequence of the inability to increase production, must inevitably go higher.

Early this year, in the Russian platinum market of Ekaterinberg, the value of the metal reached the record price of 10 roubles, 10 copecks per zolotnik (1 rouble equals 2*s.* 1⅜*d.*, a copeck equals a farthing, a zolotnik equals 65·83 grs. troy). Since then the price has slightly lowered, but it is, nevertheless, still a record average. This quotation is, of course, for the ore, 83 % metal, for export to the works to be refined in France, Germany, and England.

The production of platinum in Russia recently has been as follows : 1901, 204,870 ozs. troy ; 1908, 156,944 ozs.; 1909, 164,488 ozs. ; 1910, 176,431 ozs. The minimum production between 1901 and 1910 was, during the year 1908, due to the fall in the price of the metal, caused probably by the reserves then existing on the European markets, which had reached something like 105,330 ozs. following on over-production of the metal on the one hand, and reduced demand on the other, in view of the efforts made to find a substitute for it. About two years ago the reserves began to run down, the demand increased, and the record price was the result. The fears of the possibility of substituting other alloys for platinum proved in vain ; moreover, new discoveries of platinum so frequently announced proved to be ill-founded, and at the same time the Russian Ural supply was becoming methodically exhausted.

OTHER POSSIBLE SOURCES OF SUPPLY.

In the Rambler mine, Wyoming, platinum occurs as sperrylite, $PtAs_2$, and various other metals of the platinum group are also found in more or less important quantities. The precious metal buttons obtained by cupellation are weighed, giving the total quantity of precious metals in the ore. They are then combined in two check lots representing 4 assay tons each, and recupelled with ten times their weight of pure silver. The resulting buttons are then parted separately with 12 % nitric acid, and finally with concentrated nitric acid in test tubes placed in boiling water. Silver, platinum, and palladium are thus dissolved and gold remains. The nitric acid solution obtained is kept as small in bulk as possible. Hydrochloric acid is added to precipitate the silver as chloride, which is filtered and washed. The filtrate from the silver precipitation is then evaporated to dryness. The residue is moistened with a few drops of hydrochloric acid and taken into solution with 10 c.c. hot water. It is now made ammoniacal, then acidified with formic acid and boiled ; this will precipitate metallic platinum and palladium. Usually no precipitate forms until after boiling begins, and ebullition should be continued for half an hour. The precipitate is filtered, washed and ignited ; the weight gives the combined quantity of platinum and palladium. After weighing, the platinum and palladium are converted to chlorides by dissolving in *aqua regia*, evaporated to dryness, and taken up with a few drops of hydrochloric acid and 50 c.c. hot water.

This solution is saturated with pure crystallised ammonium chloride, 10 c.c. alcohol is added, and the whole allowed to stand for not less than 24 hours. The precipitated ammonium platinic chloride is then filtered, washed with a saturated solution of ammonium chloride, and ignited very slowly on account of the possible volatilisation of the precipitate. The resulting metallic platinum is then weighed.

In British Columbia platinum in minute quantities has been found in the peridotite of Olivine mountain situated about 7 miles from Tuldmeen. In one large sample of rock, which was worked down for diamonds, several particles of native platinum have been found. In the course of a search for the original source of the platinum of the Tuldmeen district it was found that it was often associated with chromite in appreciable quantities; in one case to the extent of $\frac{1}{2}$ oz. to the ton; another sample at the rate of 1 oz. to the ton. When examined under the microscope the platinum appears as small rounded pellets, or as thin sheets having a bright metallic lustre. The chromite segregations, however, so far as they have yet been observed, are too small and too widely separated throughout the body of the rock to make the extraction of the platinum a profitable commercial venture.

Platinum has also been found in New South Wales, Australia, where it has been mined in the central portion of the State, and the beach sands on the north coast have been treated for the metal. Up to the end of 1909 the total Commonwealth production was only 11,578 ozs., nearly the whole of which came from New South Wales. The great increase of price may induce prospectors to investigate more carefully the possibilities of platinum mining there.

In the South American Republic of Colombia the output of platinum has been the second largest in the world; it is only exceeded by that of Russia. It is always found mixed with gold, and comes from the gravels of the Choco, its main source being the rivers Platina and Condoto, which are tributaries of the San Juan River. It is also obtained from some of the streams that flow into the Atrato River. It is the general opinion that there is a great future for this branch of mining industry in the republic, and concessions granted within the last few years foreshadow the intention of exploiting it as a source of national wealth. The statistics given below show that the recent increase of price has greatly stimulated the output.

Platinum has also been obtained from Nevada, where it occurs in peridotite dikes of the enstatite-mica-picrite variety at the Key West and Great Eastern workings in the Copper King district, county Clark. The areas occur among the foothills of the Virgin range, at an elevation of approximately 3,600 ft.; they are 8 to 9 miles from the Virgin River. Besides the peridotite dikes there is also a typical hornblendite dike which shows upon analysis a trace of platinum. Alteration and concentration of the sulphides in the rock by solutions seems to increase the percentage of platinum, one analysis showing the presence of 0·55 oz. per ton. The platinum dikes as exposed upon the surface vary in width from 10 to 50 ft., and are about 100 ft. long. Platinum also occurs in seven important groups of accumulations in connection with gold placer mines of the Pacific slope. One of these is Oroville, California, where it occurs about in the proportion of 1 to 500 of gold. Other localities are Trinity County, California, and Josephine County, Oregon. On the coast, platinum is found in the proportion of 2 to 1 of gold near Surf, Santa Barbara County, but other places in the same region, including San Luis Obispo, show only 1 to 20, or 1 to 50 of gold. Another series of accumulations occurs near Trinidad Head, Humboldt County, and at Crescent City, California, and at the mouth of Smith River, and one on the South fork of that river in Oregon. The most important group of all extends from the mouth of Rogue River north to Coquille River. At Cape Blanco an accumulation of platinum has been found where that metal is five times as abundant as the gold. On the west coast of Washington it occurs in the proportion of 1 to 10 and 1 to 15 of gold.

The following statistics of imports and exports of platinum into this country and the values per ounce show the quantities absorbed by the home market and the variations in value. The United States are the largest consumers and obtain their supplies mainly from Western European works.

Our imports of platinum during recent years have been in the following quantities and values :—

	1907.	1908.	1909.	1910.	1911.
ozs. Troy	24,790	10,430	22,080	48,160	48,520
	£122,140	£45,040	£96,720	£275,510	£408,740

The fluctuations of value are shown by the following average prices per ounce :—

£ s. d.	£ s. d.	£ s d.	£ s. d.	£ s. d.
4 18 6	4 6 4	4 7 7	5 14 4	8 9 3

A portion of our imports are, of course, in the crude state.

Our exports of pure platinum are as follows :—

ozs. Troy	28,020	14,160	7,140	9,130	6,700
	£99,550	£47,130	£30,050	£43,140	£48,870

Our supplies come from the following countries; we depend mainly on France. The increased supply from Colombia is notable; it shows that the high prices have induced a more vigorous working of the deposits :—

	1907. ozs.	1908. ozs.	1909. ozs.	1910. ozs.	1911. ozs.
Russia	—	110	560	4,160	2,570
Germany	190	1,590	3,900	5,830	8,780
France	16,810	7,800	15,840	35,140	30,450
U. States	6,720	290	1,080	490	794
Colombia	—	630	70	2,030	4,910

The values of the above are as follows :—

	1907. £	1908. £	1909. £	1910. £	1911. £
Russia . .	—	430	1,720	16,360	19,380
Germany	1,330	6,220	16,950	32,170	69,340
France . .	81,720	34,350	70,160	212,260	276,280
U. States	33,480	1,120	5,230	2,100	6,480
Colombia	—	2,890	300	10,080	38,220

Our exports are mainly to Germany and France in the following quantities and values :—

Germany.

1907.	1908.	1909.	1910.	1911.
ozs. 12,270	ozs. 3,590	ozs. 3,310	ozs. 840	ozs. 2,450
£73,000	£15,780	£13,320	£5,180	£18,000

France.

ozs. 15,710	ozs. 10,510	ozs. 3,807	ozs. 7,070	ozs. 3,358
£26,370	£31,183	£16,580	£30,790	£26,200

Other Countries.

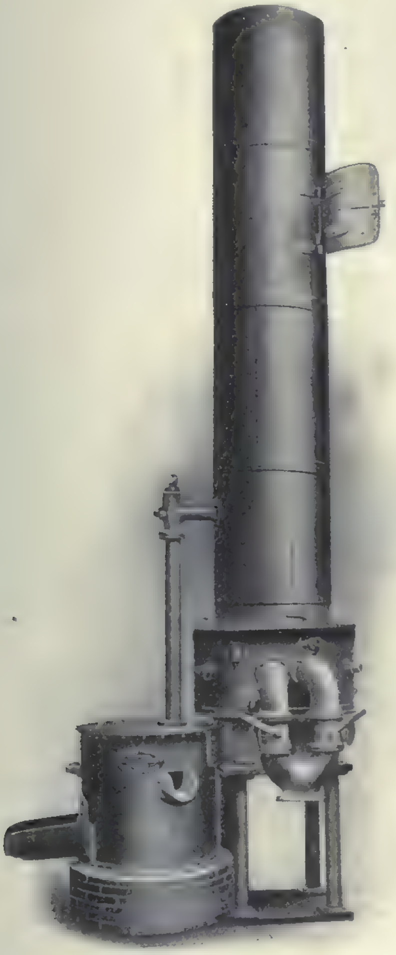
ozs. 35	ozs. 57	ozs. 29	ozs. 1,220	ozs. 890
£170	£173	£150	£7,160	£4,670

T. O.

REVIEWS OF BOOKS.

"NOTES ON FOUNDRY PRACTICE." By J. J. Morgan. CHARLES GRIFFIN & Co., LTD., London, 1912. Pages 108 + vi., including Index and 24 Illustrations. Price 2/6 net.

This small work is devoted to notes an actual foundry practice. Certain sections deal with such matters as grading and analysis of pig-iron, shrinkage and changes due to remelting. Others deal with moulding sands and foundry furnaces. The question of " mixing," which is one of such importance, is dealt with at some length ; also the principles adopted when analysis is used for this purpose. The last portion of this work is taken up with actual practice in moulding, and a description of the tools used. The section dealing with moulding machines is very short, and might with advantage have been extended to cover a description of the machines used.



THWAITES' IMPROVED RAPID CUPOLA.

The sections dealing with steel, brass and bronze are very brief, only occupying a few pages. The illustrations are good, one of which we reproduce. For its size the book seems to contain a good deal of information. The tables of analyses of typical pig-irons etc., are a useful feature.

"VOLUMETRIC ANALYSIS." By Charles H. Hampshire. J. and A. Churchill, London, 1912. Pages 104 + vi., including Index. Chapters XI. Price 3/6 net.

This small work is written chiefly for students of Pharmacy. The more general processes are dealt with in large type, while the sections in smaller type deal with processes specially required for pharmaceutical purposes.

Acidimetry and alkalimetry are dealt with, also the general question of indicators and their relative efficiency. Processes involving oxidation and reduction are then considered, and finally reactions which depend upon actual precipitation. The information contained in this work fully meets the conditions set out and it is likely to be of value to those who desire a general knowledge of volumetric analysis.

Books Received.

"NOTES ON FOUNDRY PRACTICE," by J. J. Morgan. Charles Griffin & Co., Ltd., London, 1912. Pages 108 + vi., including Index. Divided into 20 Sections with 24 Illustrations. Price 2/6 net.

"TREATMENT OF EFFLUENTS FROM DYE-HOUSES AND TEXTILE FACTORIES," by J. H. Garner, B.Sc. Society of Dyers and Colourists, Bradford, 1912. Pages 26, including 20 Illustrations. Price 2/6 net.

"THE TRANSMISSION OF HEAT INTO STEAM BOILERS," by H. Kreisinger and W. T. Ray. Bulletin 18, Bureau of Mines, Washington, U.S.A. Pages 180 + iv., including Index and 78 Illustrations.

"IGNITION OF GAS BY MINIATURE ELECTRIC LAMPS WITH TUNGSTEN FILAMENTS," by H. H. Clark. Techinal Paper 23, Bureau of Mines, Washington, U.S.A. 1912. Pages 5.

"EINFÜHRUNG IN DIE QUALITATIVE CHEMISCHE ANALYSE. ZUM GEBRAUCHE BEI DEN PRAKTISCHEN ÜBUNGEN IM LABORATORIUM," by S. Wiechowski. Verlag von Josef Šafář, Leipzig, 1910. Pages 75 + iv., Chaps. vii., including 20 Illustrations, and 1 Plate. Price M: 2.

"QUÍMICA MODERNA TEÓRICA Y SISTEMÁTICA," by Sir William Ramsay. Adrián Romo, Alcalá, 1912. Pages 654 + xi., including Index. Chaps. xi. Divided into 2 Parts, with 9 Illustrations. Price 7 Ps.

"DIE EXISTENZ DER MOLEKÜLE," by The Svedberg. Akademische Verlagsgesellschaft m. b. H. Leipzig, 1912. Pages 243 + viii., including Index. Divided into 2 Parts and 4 Sections, including 76 Illustrations. Price M: 12.

NEW METHODS OF ANALYSIS.

Estimation of Lead in Chimney Gases.[1]

It is usual to determine lead volumetrically by the "chromate" method. This consists in precipitating the lead as chromate and determining the chromic acid volumetrically by standard ferrous solution, or by means of potassium iodide (*see* Berenger, "Text-book of Assaying, 1910," p. 214). The "chromate" method is based upon the reaction—

$$K_2CrO_4 + Pb(NO_3)_2 = PbCrO_4 + 2KNO_3.$$

The reaction only proceeds normally when the chromate is in excess. If during the reaction lead is in excess and hot liquors are used, then the precipitate will carry more lead than the formula $PbCrO_4$ warrants, and the excess will vary within rather wide limits according to the manner of working. Direct titration of a lead solution is, therefore, inadmissible. An indirect method of titration has been devised, however, which appears to work well, and which has the advantage of dispensing with the use of standard solutions that change on keeping. The procedure is the following :—

A measured volume, in excess, of the standard chromate is added to the lead solution and the titration is completed with standard lead nitrate solution, using silver nitrate as indicator. Chromate is thus kept in excess until the completion of the titration, and the reaction of the liquid with the indicator yields a colour which diminishes in intensity progressively as the titration proceeds.

Procedure. Method of Titration of Lead Solution.—

Standard lead solution, 8 gms. $Pb(NO_3)_2$ per litre.
1 c.c. = approx. ·005 gm. Pb.
Standard potassium chromate, N/50 strength.
Acetate of sodium—nearly saturated solution—to which is added 40 c.c. glacial acetic acid per litre.

To Standardise the Solutions.—Add to 50 c.c. of water, 5 c.c. of acetate solution and 5 c.c. of $Pb(NO_3)_2$ solution heated to about 80° C., 25 c.c. of N/50 K_2CrO_4 with stirring; now add to the solution 0·5 to 1 gm. of precipitated calcium carbonate, heat to boiling, and run in $Pb(NO_3)_2$ solution from a burette, until a drop of the supernatant liquor drawn from near the surface by a tube with capillary end gives no perceptible colour change with a drop of N/10 $AgNO_3$. The progress of the titration can thus be watched to the finish, and at the end it is found convenient to place two drops of the supernatant liquor side by side on a tile, to add silver nitrate to one and compare the tints. The temperature of the solution at the close will be about 40° C. Dilution to 160 c.c. does not affect the result, but 85 to 90 c.c. is the volume most suitable for the test.

The calcium carbonate should be "purissimium precipitated by ammonia"; the ordinary "pure" is useless as it floats on the surface.

By this means we determine the lead equivalent of the chromate. Thus, with the solutions employed—

7·22 c.c. $Pb(NO_3)_2$ = 25 c.c. N/50 K_2CrO_4.

Titration of Lead Solution under Examination.—Add to the lead solution (50 c.c.) containing 5 c.c. of acetate solution, 25 c.c. of N/50 K_2CrO_4. If in excess, proceed as above; if insufficient to leave excess of chromate, add a further 25 c.c., followed by calcium carbonate, etc. Now run in $Pb(NO_3)_2$ solution slowly from the burette until the excess of chromate is exactly precipitated. Deduct the number of c.c. required from the standard figure 7·22 (or 2 × 7·22); the difference will be the equivalent of the lead in the solution taken.

Copper and zinc do not appear to interfere with the end-point if present in small amount, but the method is inaccurate in presence of arsenic and iron. Removal of arsenic is a troublesome matter, if other than traces are present. Joint precipitation of the sulphides and extraction of the arsenic sulphide by means of sodium sulphide proved to be an unsatisfactory method. The most convenient procedure was found to be the following :—

The solution should be evaporated with excess of sulphuric acid and gently heated to fuming point to expel nitric acid; the residue is then diluted to 10 c.c., heated to boiling point, and diluted with twice its volume of 90 % alcohol. The solution, after stirring well, is allowed to stand for 10 to 15 minutes, and is then decanted through a small filter paper, the precipitate being retained as far as practicable in the dish. The precipitate is washed two or three times with 50 % alcohol and once with 90 % alcohol, and the dish, with contained sulphate, is then dried on a water bath. The filter paper is separately dried on a glass plate and the traces of sulphate retained thereby returned to the dish; the paper is then warmed on the plate with 5 c.c. of acetate solution and the extract added to the dish and the paper further washed with water. The solution in the dish is now heated to dissolve the lead sulphate and the solution diluted to 50 c.c. and titrated as above.

If the amount of arsenic is excessive it is necessary to dissolve the lead sulphate in the dish, after washing once with 50 per cent. alcohol, with 5 c.c. of pure normal caustic soda solution with the aid of heat and to reprecipitate the lead sulphate by addition of sulphuric acid followed by addition of alcohol, etc., as described above.

If the amount of lead exceeds the equivalent of 50 c.c. N/50 chromate, the final solution should be diluted to a measured volume, and an aliquot portion taken for analysis with addition of sufficient sodium acetate solution to bring the total volume present in the titration to 5 c.c.

The following results are cited in illustration of the working of the method :—

1. Copper, zinc, and arsenic absent :—
    (*a*) Pb taken, ·005 gm. :—
        $Pb(NO_3)_2$ to finish 6·18 c.c.
            Therefore, lead present = 7·22 − 6·18 = 1·04 c.c.
            Whence, Pb found = ·005 × 1·04 = ·0052 gm.
    (*b*) Solution evaporated with sulphuric acid, filtered, etc. :—
        $Pb(NO_3)_2$ to finish = 6·26 c.c.
            Therefore, lead = 7·22 − 6·26 = ·96 c.c.
            Whence, Pb found = ·005 × ·96 = ·0048 gm.
2. Copper, zinc, and arsenic present :—
    (*a*) Pb taken, ·0025 gm. :—
        As_2O_3, 0·1; Cu(as $CuCl_2$), ·05; Zn (as $Zn(NO_3)_2$), ·05.
        Solution evaporated with sulphuric acid, filtered, etc. :—
        $Pb(NO_3)_2$ to finish = 6·81 c.c.
            Therefore, lead present = 7·22 − 6·81 = ·41 c.c.
            Whence, Pb found = ·005 × ·41 = ·00205 gm.

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[1] Mr. Linder, "Forty-eighth Annual Report Alkali, etc., Works Regulation Act, 1906."

COMMERCIAL AND GENERAL NOTES.

Paint from "Wet" Gas.

A new use has been found for natural gas in the Mid-Continent oil field of the U. S. A. A recent chemical analysis shows that "wet gas," the kind escaping from oil wells, carries a very high percentage of a raw material from which paint and ink can be manufactured. A large paint manufacturer in Oklahoma declares that enough raw material could be secured from thousands of oil wells in the Mid-Continent field to make high-grade ink and paints of various kinds in large quantities.

Paints for bridges and residences made from this source will last much longer than any known make. What is called "wet gas," or gas from wells producing oil, carries the highest percentage of by-products used in making inks and paints. The discovery bids fair to become of great commercial importance to the Mid-Continent oil fields, and a new and profitable industry is likely to be established there.

Radio-Active Minerals in Russia.

The Imperial Russian Academy of Science has received a grant of 10,000 roubles for carrying out research work in connection with the discovery of radio-active minerals.

Regulations for the Wood Alcohol Trade in Japan.

In consequence of the recent cases of poisoning by wood alcohol on the Continent, which led to strict measures for the regulation of the trade in several European countries, the Japanese Government, too, has issued new regulations. According to these the manufacture and sale of comestibles and beverages containing wood alcohol is absolutely forbidden. The sale of any article containing such alcohol is illegal, unless a label on the container clearly indicates the character of the contents. The manufacturers, dealers and importers who handle wood alcohol in any form are required to keep a trade book and make entries concerning the amount manufactured, received, transferred or sold, to whom sold and the object for which the purchaser bought the article, adding the date of sale. These books must be kept for ten years.

Synthetic Rubies and Sapphires.

An interesting commercial concern, the Deutsche Edelstein-Gesellschaft (Company for the Manufacture of Precious Stones), has recently issued its annual report, disclosing a net profit of some 16,000 marks. Although not considerable in itself, this result denotes progressive working when compared with that of last year, which revealed a net loss of nearly the same amount. The company is of recent origin and was formed to produce synthetic rubies and sapphires in the electric furnace, according to a new patented process. The well-known General Electric Company (the Allgemeine Elektrizitaets-Gesellschaft) of Berlin exercises the financial control over the Edelstein-Gesellschaft. Mention is made in the yearly report of the latter that the use of synthetic gems has recently made great strides, not only in Germany, the home of cheap jewellery, but also in the United States and other countries. They are particularly useful to the watch-making trade, possessing all the chemical and physical properties of the real stones. As the fashion is at present very favourable to sapphires and rubies, the future of the undertaking seems very promising.

The German Chemical Industry in 1911.

The enormous development of the chemical industry in Germany within recent years has been one of the most interesting features of trade expansion in the Fatherland. The prominent part which the exports of chemical products are playing can be judged from the fact that they rank fourth in the list of exported articles, and the exports of manufactured chemical products alone represent more than a third of the total production. Within a period of six years the exports of chemical and pharmaceutical products, paints and varnishes, have increased from 610,000 tons to 4,100,000 tons, and the value has risen from 309,100,000 marks to 752,900,000 marks, representing an increase of about 250 %.

The trade with Great Britain has not grown without interruptions. Especially during last year the revolution in China brought about a diminished demand for English textiles, which resulted in a reduced off-take of German dye materials. In Russia the conditions have not improved, while the exports to Japan suffered a decrease on account of the increased import duty. The Italian-Turkish war has, so far, been without bad effect on the German export trade in chemicals, causing an increased demand for special products and thus counterbalancing a diminution of the sale of others.

As far as the general sales were concerned last year they showed a satisfactory increase compared with former years, but the prices have been anything but satisfactory for the manufacturers, owing to the growth of competition and the dearness of certain raw materials. One feature of interest to English chemical firms is the absence of any strikes or labour troubles in the German chemical industry of 1911.

A survey of the financial results of seventeen leading concerns reveals the fact that two of them were able to pay dividends of 30 % (the highest amount paid), two others followed with 25 % two with 20 %, and the rest paid from 7½ % to 18 %.

The present condition of the chemical industry is considered very satisfactory. The business with the United States is influenced by the election, but will probably revive shortly. During the first six months of the current year the exports of chemical products have amounted to 461,022,000 marks, compared with 427,671,000 marks in the corresponding period of last year and 395,975,000 marks in 1910.

Ozonised Oil of Turpentine for the Manufacture of a New Washing Medium.

Dr. Fr. Hobein, of Aussig (Bohemia), has produced a new washing medium from ozonised oil of turpentine, obtained by the oxidisation of oil of turpentine with chloride of lime in alkaline solutions. The ozonised oil of turpentine is said to possess an exceptional bleaching power, and, in addition to this, to exercise a cleansing effect on linen without injuring it. The process is most practically conducted by adding soda and oil of turpentine to chloride of lime, reduced to a paste with water. As an addition to the ozonised oil of turpentine obtained by the mixture of oil of turpentine and chloride of lime, in the presence of calcined soda in excess, fluid or saponaceously solid water glass has proved advantageous, the surplus soda in the washing medium acting as water absorbent. M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

14628/11. F. L. TEED, H. L. SULMAN and H. F. K. PICARD, London. **Sulphur Recovery.** 20 June, 1911.

The process, according to this invention, for the recovery of sulphur from gases containing oxides of sulphur consists in mixing the sulphurous gases with non-sulphurous reducing gases, or a mixture of non-sulphurous reducing and inert gases, and bringing them into contact at a suitable temperature with a solid contact agent, such as spongy platinum, to bring about the reaction between the gases. (4 claims.)

17714/11. A. LIETZENMAYER, Aix-la-Chapelle, Germany. **Paper Manufacture.** Dated, under International Convention, as 3 August, 1910.

This process for treating raw substances and old materials, such as cellulose-containing substances such as wood sawdust, printed paper or manuscripts, waste cardboard and the like, for the manufacture of paper, differs from the ordinary process mainly by the grinding operation being replaced by a combined chemical and mechanical process of the materials to be prepared, namely, by the addition of a lye and then, after disintegration is complete, the separation of the liquid by mechanical means from the pulped material and from the colloidal impurities taken up by the liquid from the pulped material. (4 claims.)

17822/11. J. AKTSCHOURIN, Tupik, Russia. **Resin Soap.** 4 August, 1911.

The process for the manufacture of resin emulsions and resin soap consists, according to this invention, in treating shavings or the like of resinous trees with a diluted solution of alkali of between 5° and 8° Bé. under a pressure of several atmospheres at a temperature below 100° C. After the saponifying process and the separation of the resin are complete, the liquid, in the form of a mixture of soap-glue and resin emulsion, is separated from the shavings in centrifugal machines. (1 claim.)

18041/11. W. POWELL, London. **Seasoning Timber.** 9 August, 1911.

The process of treating or artificially seasoning timber, according to this invention, consists in immersing the wood in a saccharine solution at about 140° F., then raising the temperature of the solution and maintaining it at approximately the boiling point, cooling the liquid down to about 140° F., and finally removing the wood and allowing it to dry naturally or placing it in a drying chamber. (3 claims.)

21014/11. C. V. THIERRY, Paris. **Metallurgy of Zinc.** 22 September, 1911.

A process for the extraction of zinc from blue powder produced during zinc smelting consists in washing the powder with an acid in very small quantities, as, for example, by diluting the acid with water, which acts on the covering of the particles to form a compound soluble in water. (5 claims.)

56/2. A. RICHARDS, London. **Recovery of Tin.** 1 January, 1912.

The process for recovering tin from tin-bearing substances or materials consists, according to this invention, in converting the tin into vapour or fume by heating it in close conjunction with a suitable reducing agent and any suitable solid chlorine or bromine-bearing substance (other than common salt) which is capable of attacking the tin in the presence of the reducing agent and with the necessary application of heat. (6 claims.)

3410/12. A. SCHWEITZER and F. HAUFF, Stuttgart. **Nitrogen Compounds.** Dated, under International Convention, as 10 February, 1911.

This invention relates to the manufacture of nitrogen compounds by electrically heating quantities of compounds of the alkalis or alkali earths in the presence of carbon and in an atmosphere of nitrogen. The invention consists substantially in that the reaction charge, *i.e.*, a mixture of alkali or alkali earth metal compounds and carbon, is continuously guided through an electrically heated zone in a form allowing conductance of electric current and permeable to gas when heated, in a direction opposing a current of nitrogen containing gas, the charge constituting an electrical resistance in the heating zone. (4 claims.)

8348/12. SOCIÉTÉ GÉNÉRALE DES NITRURES, Paris. **Aluminium Nitride.** Dated, under International Convention, as 9 December, 1911.

The invention relates to a process for the manufacture of aluminium nitride consisting in heating a mixture of carbon and alumina or aluminous substances (bauxite, kaolin) in a current of nitrogen containing free or nascent hydrogen, that is to say, hydrogen in the form of a compound decomposing at the temperature of the reaction, but of which the other constituents would not affect the latter. (1 claim.)

8349/12. SOCIÉTÉ GÉNÉRALE DES NITRURES, Paris. **Aluminium Nitride.** Dated, under International Convention, as 10 January, 1912.

The formation of aluminium nitride by the action of a current of nitrogen upon a mixture of carbon and alumina at high temperatures is facilitated when certain metallic oxides or hydroxides are added. The reaction is also facilitated when there are added to the nitrogen serving for the reaction varying quantities of hydrogen in the free or nascent state. The present invention is based upon the following fact :—It has been found that the simultaneous addition of hydrogen to the reacting nitrogen, and of oxides, hydroxides, metallic carbonates, and even metals, to the solid mixture of alumina and carbon, increases the fixation of nitrogen to an extent much greater than was to be anticipated. (1 claim.)

11271/12. E. BALLEGEER, Brussels. **Electro deposition of Zinc.** 11 May, 1912.

The invention relates to galvanic deposits produced by electrolysis, and has, more particularly, for its object to provide a new process of cold galvanisation, the essential feature of which is a special composition of the galvanic bath. The bath is composed of water, a zinc chloride solution of 46° Bé., chloride of ammonia, chloride of sodium, and tartaric acid, these substances being preferably used in the following proportions :—water, 100 litres ; $ZnCl_2$, 40 litres ; NH_4Cl, 8 kilogrammes ; NaCl, 2½ kilogrammes ; and tartaric acid, 2½ kilogrammes. (2 claims.)

THE CHEMICAL WORLD

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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MATHEMATICS AND THE IMPERIAL COLLEGE.

A RECENT letter written by Professor John Perry to *Nature* (September 12th, 1912), once more brings to the front, the question of the teaching of mathematics in our colleges and universities. Professor Perry has deliberately thrown down the gauntlet, and challenged Sir William White to show, that certain changes in the method of teaching mathematics, which he announced as contemplated at the Imperial College of Science and Technology, will not involve a retrogression in the teaching of science in this country.

The writer states his case with a directness which is entirely characteristic. He claims that in initiating the experimental method of teaching mathematics, first at the Technical College of the City and Guilds of London, at Finsbury, and afterwards at the Royal School of Mines at South Kensington, he introduced a system which has since been adopted in nearly all engineering colleges and polytechnics both here, in America, Germany, and many other foreign countries, and one which has received the unqualified support of such judges as the late Lord Kelvin.

Professor Perry claims to have initiated a revolution in the methods of teaching this subject. "Twenty years ago," he writes, "mathematics continued to be taught in a way which may be called the orthodox way—a way which succeeded fairly well with students who were fond of abstract reasoning, 3% of all students, and quite failed with the other 97%." He further claims that Sir William White's opinion, as expressed at the International Congress of Mathematicians at Cambridge, can only apply to the normal conditions in civil, or mechanical, engineering of a period which has passed away; and joins issue with Sir William when he indicates that "professional mathematicians," and not teachers who may be engineers or men acquainted with engineering science, will be responsible for the mathematics taught at the Imperial College, after Professor Perry has followed Professor Henrici into retirement.

It is difficult to believe that a step of the nature indicated, involving as it does a virtual divorce between mathematics and practical engineering, can be contemplated at the Imperial College of Technology. We can hardly think that the large number of students who have studied under Professors Perry and Henrici can have failed to realise the true inwardness of this modern method of teaching, and the general advance achieved from a practical point of view; or that they will tolerate such a step as that indicated, without a very definite protest. We deal with this matter in the belief that the chemist has already realised the importance of a training in practical mathematics, and the adverse influence its absence will entail on students in one of our leading centres of education.

Concerning the appointments of "professional mathematicians," Professor Perry says:—

> "This has been tried often enough, and it has always been found that the one or two good students take a distaste to practical engineering, and the average student is never brought beyond the direct elementary work, and he hates the appearance of a mathematical symbol all his life after. The average student cannot understand abstract reasoning; his teacher has no knowledge of him, and pursues his serenely ignorant way, wondering how it is that so many students are stupid, or else wonders that he, and a few other men, should be so supremely clever. He never studies his pupil. There are men who can train any animal; they study its habits of thought; they are kind and sympathetic. The poor average English boy is never studied by the professional mathematician."

It was hoped that the establishment of a college like the Imperial College of Science and Technology, founded as it was with much beating of drums, would secure to the Metropolis an institution which might be regarded as an equivalent to that of the far-famed one at Charlottenberg. Its course of instruction was to have a direct bearing on the application of science to industry.

It will apparently be increasingly necessary, in the interests of the educational position of London, that certain future developments shall be carefully watched. The policy of a mere shuffling of cards, or an occasional flutter of excitement over a staff appointment, will never give to London the position it should occupy.

Beyond all question, the Imperial College of Science and Technology should be the most up-to-date, comprehensive, and practical institution of its kind in this country. Its programme should crowd its lecture-rooms and laboratories with students. It should present a standing example of efficiency to the other technical colleges in this country. It cannot be claimed by its most fervent advocate that the College occupies any such position, or is seemingly likely to do so, in the near future. The matter is one of such general importance that we hope to return to it on a future occasion.

Kaiser-Wilhelm Institute.

The recent publication of Emil Fischer's lecture in book-form has brought prominently before the public the aim and object of this new Institution, which has been promoted by the German Society for the Promotion of Science.

It is interesting to note that although members of the staff in the German Universities have for years tried to interest the wealthy members of the community in this scheme, it was not until the German Emperor personally considered this matter that it received the desired support.

The object of this Institution is to "promote the sciences, especially by the foundation and support of scientific institutes of research."

The present position of Germany in the application of science to industry is certainly a satisfactory one. It has been claimed that the advance to the present condition has occurred in a country where "the process of training has gone on for nearly a hundred years," and where rewards have been given "not to successful examinees, and not in the form of scholarships, but have been earned in the battle of life for which ample preparation has been given."

This is in a country where one industrial combine alone (according to Professor Fischer), employs 700 chemists (a number which is equal to half the total membership of the Institute of Chemistry); where the total annual value of the products of chemical industry amount to £750,000,000, giving employment to 200,000 persons in their production.

This Institute is apparently founded upon the belief that "science, like virtue, brings its own reward," and upon a national feeling which it is claimed has engendered "a deeper understanding of scientific achievements and their bearing on industry."

Professor Huxley in 1877 remarked:—

> "I would make accessible the highest and most complete training the country could afford. Whatever that might cost, depend upon it the investment would be a good one. I weigh my words, when I say that if the nation could purchase a potential Watt, or Davy, or Faraday, at the cost of a hundred thousand pounds down, he would be dirt-cheap at the money. It is a mere commonplace and everyday piece of knowledge, that what these three men did has produced untold millions of wealth, in the narrowest economical sense of the word."

This further development, as Professor Fischer has pointed out, comes on the crest of a wave of activity. He says:—

> "No one will be able to assert that experimental research in Germany has been neglected; exactly the opposite conclusion must be drawn on contemplating the history of science during the nineteenth century. This displays a long series of brilliant scientific discoveries. The industries closely connected with science, such as the chemical and electrotechnical industries, fine mechanical engineering, metallurgy, industries connected with fermentation, and last, but not least, agriculture, have also undergone in our hands a development envied on all sides.
>
> "If a criterion of the results of experimental research be desired, this may perhaps be found in the distribution of the Nobel prizes, which are awarded by absolutely independent corporations in Sweden. Only a month ago, 1910, the Nobel prize for chemistry came for the sixth time to Germany; this constitutes 60% of all the Nobel prizes hitherto awarded for chemistry. During the same period of time two and a half prizes were awarded to Germans for physics, and three and a half for medicine. Dr. Alfred Nobel, unfortunately, did not provide for the remaining natural sciences."

We must congratulate our German *confrères* on the further advance which is recorded in the establishment of this research institution, and in the characteristic way it is to be conducted.

Procter Research Laboratory.

In connection with Professor Procter's retirement from the Chair of Leather Chemistry at the Leeds University in 1913, it has been proposed by our contemporary *The Leather Trades Review* that a fund should be raised for the endowment of a Procter Research Laboratory—preferably connected with the above University—which should be devoted to scientific research in connection with the more difficult problems in tanning, to which Professor Procter has of recent years given special attention.

Dr. Gordon Parker, in his presidential address at the recent International Congress of Leather Trades Chemists, alluded to the matter in general terms, and certainly the suggestion was received with a good deal of enthusiasm. He pointed out how closely Professor Procter has been associated with the application of scientific knowledge to the leather industry in this country, and to the results obtained. These have indirectly led to the further establishment of the Leathersellers' Technical College, Bermondsey, and other developments on a possibly less ambitious scale elsewhere. There can be little doubt that this movement will receive general support, and it is hoped that the financial side will not present difficulties which cannot be surmounted. We note that Professor Procter has been appointed to the newly constituted office of Honorary President of the International Association of Leather Trades Chemists.

THE CHEMISTRY AND FUNGICIDAL ACTION OF BORDEAUX MIXTURE.

By C. T. Gimingham, F.I.C., University of Bristol.

A large number of different preparations have been used at various times for the purpose of combating the numerous diseases of cultivated plants which are caused by parasitic fungi. Most of these preparations take the form of a liquid containing some substance either in solution, or suspension, which when sprayed on to the surfaces liable to infection will prevent the attack of the parasite, or, if it is already established, will destroy it. To be commercially valuable such a spray-fluid must possess a high efficiency as a fungicide, whilst at the same time injuring the leaves or fruit of the host plant as little as possible; it must also be cheap and simple to prepare and apply.

This particular combination of qualities is not very easily hit upon, for many substances which would effectively destroy parasitic fungi are not available for this purpose on account of their equally destructive action upon plant tissues. Thus, it was known as early as the beginning of the nineteenth century, that a solution of copper sulphate possessed fungicidal properties; and this solution is still in use for winter spraying of the wood of fruit trees and for the treatment of seed wheat to prevent the germination of the spores of wheat "smut." It cannot, however, be used as a general summer fungicide because, under ordinary conditions, serious damage to foliage follows its application. It was not until 1882 that Professor Millardet, of Bordeaux, discovered that a mixture of copper sulphate with lime could be employed without much damage to the leaves, for holding in check the ravages of vine mildew (*Peronospora viticola*). This preparation, since known universally as Bordeaux mixture, has now been for some time in common use in many countries as a general fungicide. In the years immediately after its discovery experiments were made with various copper compounds, the best results always following the use of Bordeaux mixture; and it is now by far the most important commercial fungicide and is employed very largely indeed as a remedy for potato disease and for the numerous fungus diseases of fruit trees. Bordeaux mixture causes the minimum of harm to the sprayed plant (though the injury or "scorching," as it is called, under certain conditions is by no means negligible) but is none the less a very effective fungicide; it is both cheap, safe, and easy to use, and in addition possesses some beneficial physiological action upon the plant—not yet wholly explained—apart from the actual protection against parasites.

The proportions most commonly employed in making the mixture are:—

Copper sulphate (cryst.) ..	8 lbs.
Quick lime	8 lbs.
Water	100 gallons

though for particular purposes the proportion of copper sulphate is sometimes decreased or increased, always, however, leaving the lime in considerable excess.

In preparing the mixture, the milk of lime and the copper sulphate solution are well diluted before mixing, the copper then being precipitated in a finely-divided somewhat flocculent condition. Only the very slightest trace of copper is detectable in solution, and the clear liquid obtained on allowing the precipitate to settle possesses no fungicidal properties. It is therefore essential to keep the fluid well agitated during actual spraying; and the nozzle through which it is forced must be so constructed as to give a fine misty spray which will coat all parts of the plant with a thin uniform deposit.

It is somewhat remarkable in view of the importance of the subject that until recently the chemistry of Bordeaux mixture has received but little attention. A comprehensive literature exists dealing with various problems that arise, and many theories have been put forward to explain the fungicidal action; but, prior to 1907, all the work had been carried out without an adequate investigation of the chemistry of the compounds involved. The statement that the insoluble copper precipitate consisted of copper hydroxide was for the most part accepted as correct, though one or two writers refer to the probability of basic sulphates also being present.

Pickering has now shown (*Journ. Chem. Soc.*, 1907, 1988) that the addition of lime in gradually increasing amounts to a solution of copper sulphate results in the formation, not of copper hydroxide, but of a series of basic sulphates of copper. In ordinary Bordeaux mixture (*i.e.*, made from equal weights of copper sulphate and lime) the formula of the final compound present is given as $10CuO, SO_3, 3CuO$ in presence of large excess of free lime; whereas if no excess of lime is present, the composition of the compound may be either $4CuO,SO_3$, $5CuO,SO_3$ or $10CuO,SO_3$, depending on the proportion of limewater added. In the same paper Pickering shows that the action of carbon dioxide on these compounds is to bring copper into solution. He gives the following equation:

$$10CuO,SO_3 + 4{\cdot}5CO_2 = 4{\cdot}5\ (CuO)_2CO_2 + CuSO_4$$

and considers that in practice soluble copper will be produced in this way by the action of atmospheric carbon dioxide.

This suggestion brings us directly to the much-debated question of the nature of the fungicidal action of Bordeaux mixtures. It is not difficult to understand the direct poisonous action of *soluble* copper compounds, but in Bordeaux mixture the copper is present solely in an *insoluble* form, and in order to explain its action in practice many theories have been brought forward. There appear to be three possible alternatives:

(1) That a purely chemical process is concerned, soluble copper being produced by atmospheric agencies, especially by the CO_2 of the air.

(2) That the fungus itself dissolves sufficient of the insoluble copper deposit to cause its death.

(3) That the foliage of the sprayed plants exercises a solvent action on the copper deposit.

Millardet and Gayon (*J. d'Agr. Pract.*, 1887) were the first to suggest the agency of atmospheric carbon dioxide in bringing copper into solution, and this view has been elaborated by Pickering. To the copper sulphate formed according to the equation given above, he attributes the main fungicidal action of Bordeaux mixtures. This explanation is based on a series of experiments (*see* 11th Rpt. Woburn Expt. Fruit Farm, 1910: also *J. Agric. Sci.*, III., 171) upon the action of a stream of CO_2 on mixtures of copper sulphate and limewater in different proportions. When the proportions employed were such as to form the compounds $4CuO,SO_3$ or $10CuO,SO_3$, the action of CO_2 brought copper into solution rapidly. When ordinary Bordeaux mixture was used (large excess of lime) very little copper appeared in solution until all the free lime had been carbonated. Pickering, therefore, considers that Bordeaux mixtures made without excess of lime will be more efficient than the ordinary mixture.

In the course of some work on the subject, it was noticed by the present writer that all the copper brought into solution by the action of CO_2 for a short length of time on the compound $10CuO,SO_3$ was entirely reprecipitated on removal of the CO_2 (*see J. Agric. Sci.*, IV., 1911, *p.* 69). The copper sulphate set free according to Pickering's equation is really removed from solution as it is formed, and the soluble copper actually found in these experiments is in the form of a carbonate dissolved in the CO_2 solution, which precipitates out as the gas escapes. It can be shown that copper sulphate in presence of unchanged $10CuO,SO_3$ combines, up to a certain amount, to form a lower basic sulphate, and only whilst there is a large excess of CO_2 (such as could hardly occur out of doors) is an appreciable amount of copper brought into solution; and only under those conditions would any copper so dissolved remain in solution. In view of these observations it is difficult to see how in practice any soluble copper would be produced by the action of the CO_2 in the air. Further experiments designed to test the theory under conditions more like those actually found in practice lead to the conclusion that "although the action of CO_2 in excess upon the compounds present in Bordeaux mixtures brings copper into solution, yet it appears impossible to assign the fungicidal action to copper sulphate liberated by *atmospheric* carbon dioxide." Some alternative to this purely chemical explanation seems necessary.

The possibility of a direct solvent action between the fungus itself and the Bordeaux mixture precipitate, though frequently suggested, could not be said to have been demonstrated. In a recent paper (*J. Agric. Sci.*, IV., 1911, 76) Barker and Gimingham describe experiments made with the object of gaining further information upon this point. The action of Bordeaux mixture with no excess of lime present, and of the filtrate from the mixture, upon spores of various fungi (*Nectria*, *Puccinia* and *Sclerotinia*) has been investigated; and the results furnish strong evidence in favour of the view "that certain fungi at least are able to act upon the insoluble copper compounds sufficiently to poison themselves, *provided they are associated closely enough with it.*" The question of distance between the copper particles and the fungus is the matter of prime importance. By the use of diffusion tubes in order to prevent direct contact between the copper particles and the spores, it was shown that the latter apparently exerted no appreciable solvent action at a distance from the copper, nor did the minute traces of that substance which are present in solution act as a cumulative poison; the suggestion favoured by Pickering in a more recent paper (*J. Agric. Sci.*, IV., 1912, 273). Outside the diffusion tubes, and also even inside, so long as there was not actual contact with the Bordeaux precipitate at the bottom of the tube, the fungus spores germinated and grew freely. Further experiments have given confirmative results, and it seems reasonable to suppose that in practice the fungus will exert a solvent action sufficiently strong to kill itself when direct contact with the copper deposit occurs. Such action will be local and will not result in the production of soluble copper outside the fungus, so that no general fungicidal action need come into play.

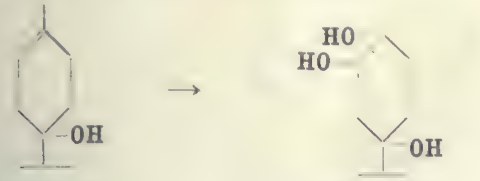
With regard to the third of the headings mentioned above—a solvent action by the sprayed foliage—the whole of the evidence obtained goes to show that *uninjured* leaves of most ordinary plants do not exert any such solvent power. On the other hand, *injured* foliage unquestionably does possess a distinct solvent action, even although the injuries may be almost microscopic. This is an important point since, certainly from the middle of the summer onwards, it is very difficult to find any number of leaves which are perfectly free from injuries or abrasions of one sort or another, due to insect attacks, to wind damage or other causes. Hence the production of some soluble copper on sprayed trees by excretions from injuries is a factor to be taken account of in this connection; and it is worth remarking that the "scorching" which so often follows spraying is in all probability started mainly by copper dissolved in this manner. On the whole, however, it seems probable that the most important factors concerned in the fungicidal action of Bordeaux mixtures are not those by which soluble copper is produced; but that the actual contact, or very close association between the fungus and the particles of the insoluble copper compound, resulting in just enough absorption of copper to cause death, is the chief means by which the mixture is effective.

THE TERPENES.

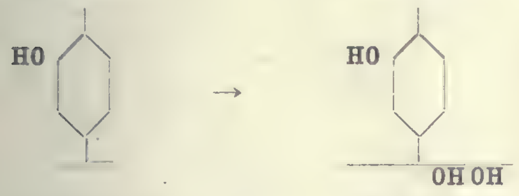
By PROFESSOR J. B. COHEN, B.Sc., Ph.D., F.R.S., UNIVERSITY OF LEEDS.

(*Continued from p.* 332.)

THE initial changes mentioned in the last paragraph of the preceding article (p. 332) will be represented in the two cases as follows :—

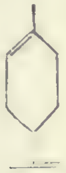


Terpineol ($\Delta' p$ Menthenol). Trihydroxy derivative.



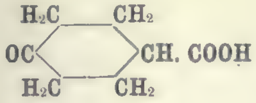
Dihydrocarveol ($\Delta^{8(9)}$ Menthenol). Trihydroxy derivative.

It therefore follows that as dipentene is related to both, it must share both double bonds :—

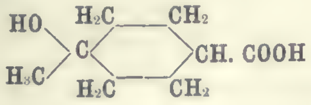


Dipentene (limonene).

This formula has been confirmed by Perkin. Leaving out the initial stages of the preparation, Perkin and Kay, in 1904, obtained a ketonic acid of the formula :—

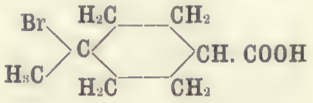


The ester was treated by Grignard's reaction with magnesium methyl iodide, which yields the following :—

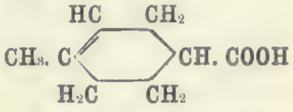


1 Methyl-cyclohexanol 4 carboxylic acid.

When the hydroxy- acid is heated with hydrobromic acid it is converted into the corresponding bromine derivative from which alkalis remove hydrogen bromide giving an unsaturated acid :—

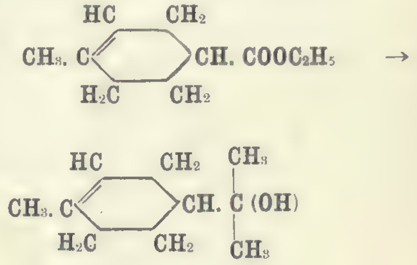


1 Methyl 1 bromocyclohexane. 4 carboxylic acid.



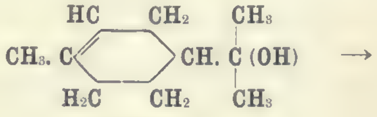
1 Methyl Δ' cyclohexene. 4 carboxylic acid.

The next step was to convert the unsaturated acid into its ester, and the final step to submit the product again to the action of the Grignard reagent :—

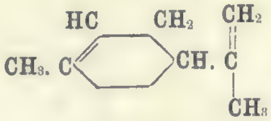


Terpineol.

The compound obtained was terpineol above referred to, identical with the natural product, and which by the action of potassium hydrogen sulphate yielded dipentene by loss of water :—

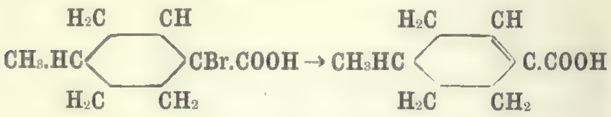


Terpineol.

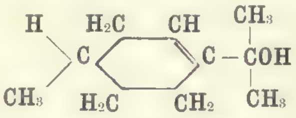


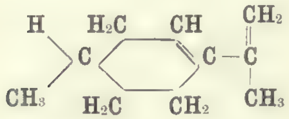
Dipentene.

The terpineol obtained in this way is inactive, whereas the natural terpineol is active. The active substances were prepared by resolving the unsaturated acid into its active constituents before the final treatment with the Grignard reagent. Thus, no single property differentiated the artificial and natural products. With slight modifications this may serve as the type of all subsequent syntheses. Thus, p-toluic acid yields on reduction the hexahydro derivative (1 methyl cyclohexane, 4 carboxylic acid); on bromination and subsequent removal of hydrogen bromide an unsaturated acid is obtained by the following series of changes :—



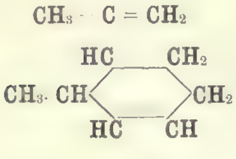
The subsequent steps are the same as the preceding, the final menthenol and menthadiene having the following formulæ :—



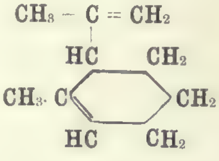


Like dipentene, this menthadiene smells of lemons, but it boils at a higher temperature, has a higher refractive index, and only combines with one molecule of bromine and one of hydrogen chloride and bromide, whereas dipentene unites with two. This is explained on Thiele's theory of *conjugated* double bonds—C : C-C : C—a structure which is known to behave in this way, and is therefore present in the above terpene. The unsaturated acid, which contains an asymmetric carbon atom, was resolved into its active constituents, and the terpene eventually obtained in two active forms.

The ortho-menthadienes and menthenols have been synthesised in much the same manner as the para-menthadienes and menthenols above described from o-toluic acid in one case and o-hydroxy-o-toluic acid in the other. The products were Δ^5 and Δ^6 o-menthadienes.

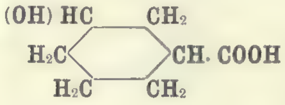


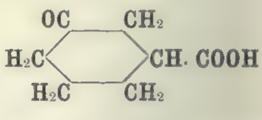
Δ^5 o-menthadiene.



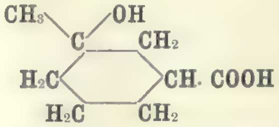
Δ^6 o-menthadiene.

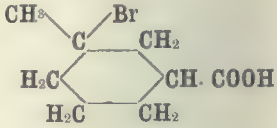
In the meta-series the full number of possible menthenols and menthadienes have also been prepared. Like the preceding, the menthenols are colourless, viscid oils which possess in a very remarkable degree the odour of terpineol and menthol. They, and the corresponding menthadienes, are characterised by the intense violet colouration which a drop of sulphuric acid produces when added to a solution of the substance in acetic anhydride. Now this reaction was first observed in the case of *sylvestrene*, a terpene found in *pinus sylvestris* by Atterberg in 1877, and later in that of *carvestrene*, a synthetic product obtained from carvone by Professor v. Baeyer in 1894. It was then proved that both substances were m-menthadienes, sylvestrene being one of the active forms (dextro) of carvestrene. These facts have since been confirmed by Perkin's synthesis. The following are, briefly, the steps. The starting point is m-hydroxybenzoic acid, which is reduced with sodium and alcohol to cyclohexanol carboxylic acid. The latter is converted by oxidation into the ketone.



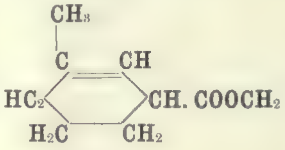


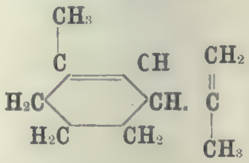
When the ester of the ketonic acid is submitted to the Grignard reaction, methyl and hydroxyl are introduced in place of ketonic oxygen. Hydrogen bromide then replaces the hydroxyl by bromine.



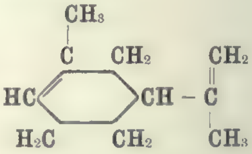


Finally, hydrogen bromide is removed and the ester again treated with the Grignard reagent, yielding the menthenol and the menthadiene.



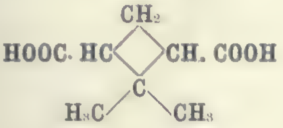


The product was identical with carvestrene. By resolving the above bromo acid into its active components, the dextrorotatory sylvestrene was obtained. As the removal of hydrogen bromide in the above reaction may take place in two directions, it is still doubtful whether carvestrene and sylvestrene may not have the formula :—

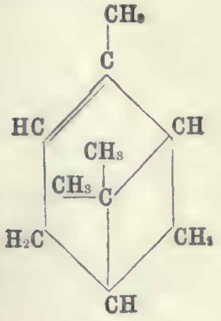


and it is not improbable that the natural and artificial products are mixtures of both.

The most interesting of all the terpenes is the one most plentifully obtained, namely, pinene, the chief constituent of turpentine oil. It is not only of great commercial importance as a vehicle for pigments and as a constituent of varnishes, polishes and medical preparations, but has recently received a new application in the manufacture of artificial camphor. It possesses a special interest for the chemist on account of the remarkable diversity of changes which it undergoes. It is a veritable chemical kaleidoscope. Before attempting to explain these changes a word must be said about its structure. That it possesses a structure which readily yields a monocyclic terpene of the *p*-menthadiene series may be shown by its behaviour with acids which convert it into a mixture of dipentene, terpinene and terpinolene. That it also contains a four-carbon ring is proved by its conversion into norpinic acid by oxidation.


Norpinic acid.

The presence of an ethylene linkage is shown by its union with a molecule of hydrogen chloride or bromide or nitrosyl chloride. Putting these and certain other facts together, the following formula seems fairly well established :—

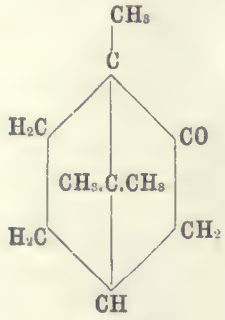

α Pinene.

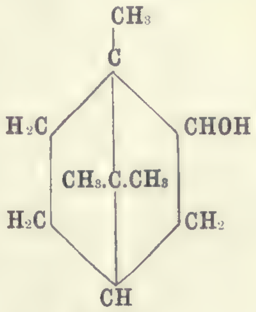
When dry hydrogen chloride is passed into turpentine oil a colourless, crystalline product of the formula $C_{10}H_{16}HCl$ is formed. This substance, from its appearance, but more especially on account of its smell, has received the name of "artificial camphor," although it possesses few of its properties. Pinene cannot, however, be regained from the hydrochloride by removing the acid. The product is a new solid terpene which has been termed camphene. What its exact structure is, is not yet definitely ascertained; but it is probably represented by the formula on p. 368. Camphene is found in nature in various essential oils in both dextro and laevo forms. If in place of dry hydrogen chloride, pinene is acted upon by the moist acid, two molecules of hydrogen chloride are taken up, and a dihydrochloride is formed identical with dipentene dihydrochloride. Let us examine each of these reactions separately.

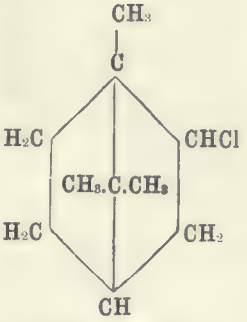
The first reaction, in which the additive compound with one molecule of acid is obtained, is called bornyl chloride, for it is formed from *borneol* or Borneo camphor. Borneo camphor is found in nature, but it may also be obtained by the reduction of camphor. Thus, we have a direct connection between camphor and pinene—

$$\underset{\text{Camphor.}}{C_{10}H_{16}O} \longrightarrow \underset{\text{Borneol.}}{C_{10}H_{17}OH} \longrightarrow \underset{\text{Bornyl chloride.}}{C_{10}H_{17}Cl} \longleftarrow \underset{\text{Pinene.}}{C_{10}H_{16}}$$

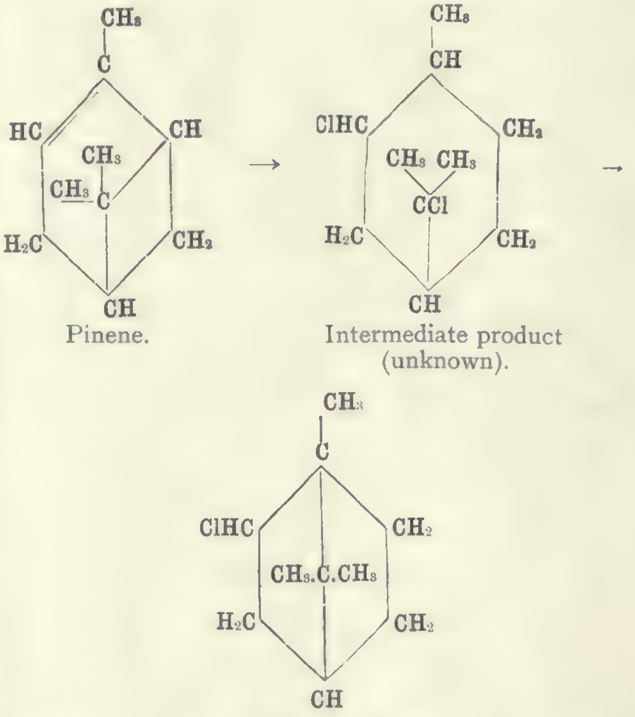
Translated into structural formulæ the first three appear thus :—


Camphor.


Borneol.


Bornyl chloride.

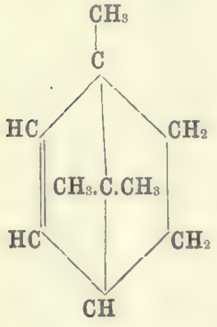
In order to explain the conversion of pinene into bornyl chloride of the above formula, it may be assumed that two molecules of hydrogen chloride are added and that one is immediately removed.

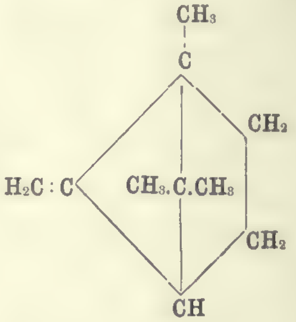

Pinene.

Intermediate product (unknown).

Bornyl chloride.

Under certain conditions bornyl chloride may be induced to yield, not camphene, but the isomeric bornylene, so that bornyl chloride breaks up in two directions at the moment the molecule of hydrogen chloride is removed.

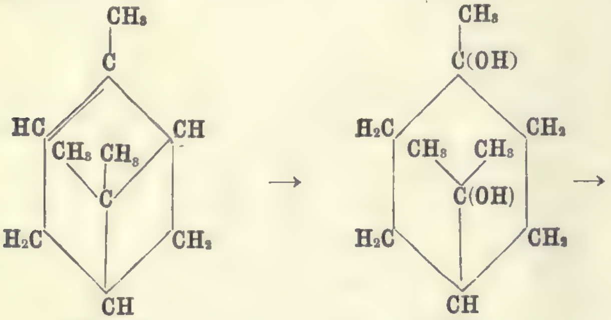

Bornylene.


Camphene.

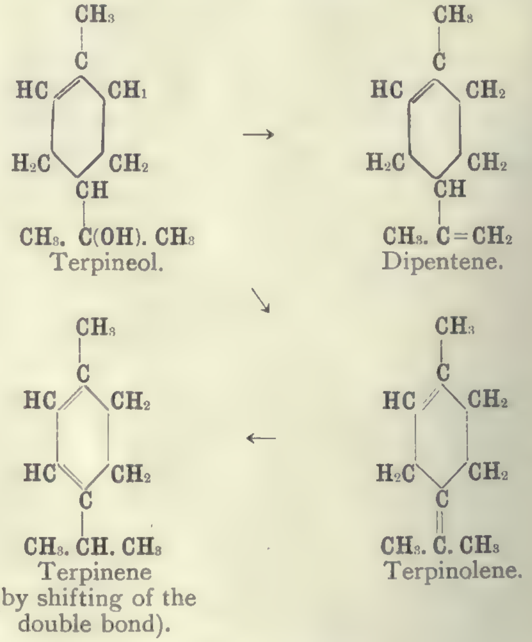
Now, when camphene unites with hydrochloric acid again, or with an organic acid under the influence of sulphuric acid, it does not re-form bornyl chloride nor an ester of bornyl alcohol, but isomeric compounds, termed isobornyl chloride or camphene hydrochloride and isobornyl esters. These esters on hydrolysis yield an isomeric borneol, called isoborneol. What the exact relation of the isobornyl to the bornyl compounds is, is still under discussion; but they must be very closely connected, since isoborneol, like borneol, yields camphor on oxidation. This, in outline, represents the commercial method of producing camphor from pinene. The steps are briefly as follows: pinene, bornyl chloride, camphene, isobornyl ester, isoborneol, camphor. Thus, we have tried to trace the relation between turpentine oil and camphor, a relation which forms the basis of the commercial process.

The solution of the other part of the problem, the relation of pinene to dipentene and the other monocyclic terpenes, is a comparatively easy task. It is well known that by acting on turpentine with alcoholic sulphuric acid or oxalic acid a mixture of dipentene, terpinene and terpinolene, as well as terpineol, is obtained, and that alcoholic nitric acid produces terpin hydrate, $C_{10}H_{18}(OH)_2 . H_2O$, a compound which can also be prepared from dipentene dihydrobromide.

Let us suppose that a change occurs similar to that by which pinene is converted into bornyl chloride, only that a process of hydrolysis or addition of the elements of water, followed by their removal is effected. The following changes will probably occur:—


Pinene. Terpin.

Pinene first forms terpin by the addition of two molecules of water, one of which it loses, yielding terpineol. The loss of the second molecule may produce, with or without a shifting of the double bond, one or all of the three terpenes, dipentene, terpinene or terpinolene.


Terpineol. Dipentene. Terpinene (by shifting of the double bond). Terpinolene.

Regulations for Control of Fertiliser Trade in Japan.—The principal points of the revised regulations, which considerably modify those promulgated in 1908 (see *Board of Trade Journal* of August 5th, p. 290), are, roughly as follows:—

1. So far as retail merchants are concerned, the ingredients and proportions of mixed fertilisers need not be printed upon the bags in which they are packed.

2. When applying for permission to engage in the fertiliser trade, a scale of ingredients is no longer required to be stated.

3. Notice of the retail price of fertilisers need no longer be given to the authorities.

4. Conference with the chief local official concerned is not necessary when permit is granted to engage in the fertiliser trade.

5. When fertilisers are split up into small lots for sale, a certificate of guarantee need not be annexed. [Hitherto, when a merchant opened a bag or sack and split it up for sale, it has been his duty to attach a certificate of guarantee in each case; this is now no longer required.]

6. Importers of fertilisers may now import into any port they wish. [Hitherto, the place of import had to be specified in the original application of the importer to engage in the fertiliser import business, and any change in such place had to be notified to the authorities.]

7. Hitherto, notice to the authorities has been necessary *before* each importation of fertilisers. Such notice may now be given immediately *after* importation. Moreover, notice of import is no longer required in the case of beancake.

8. Another important indirect effect of the revised regulations is to free the retail merchant from responsibility as to the ingredients of the fertilisers in which he does business—such responsibility resting entirely with the manufacturer and importer.—*Board of Trade Journal.*

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

SOME ASPECTS OF THE RESIN AND WOOD PULP INDUSTRIES.

By J. F. BRIGGS, A.C.G.I.

ALTHOUGH chemists in this country are not directly concerned with the technical problems of either the resin industry or the wood pulp industry, a short statement of some of the problems now in course of solution may prove of interest, more particularly to those engaged in the paper trade who find themselves faced with a serious upward movement in the price of both these materials. So far as the rise in wood cellulose is concerned, we may content ourselves with the reflection that the causes are largely temporary, depending chiefly on the cycle of good trade following the period of depression which reached its lowest point in 1908. So far as the increase in consumption is permanent, we may rest assured that it can be met and will be met by an extension of the sources of supply in one direction or another. But in the case of resin the commercial position is a very different one; the area of production is extremely limited, the methods of collection have for a long time been crude, wasteful and destructive, and the increase in consumption tends to be permanent and progressive. This position has been largely brought about by the appreciation in the value of vegetable fats by improved methods of refining for edible purposes, so that the butter-maker draws on the materials of the soap-maker, and the latter in his turn bids against the paper-maker.

For an account of the resin and turpentine industry we cannot do better than refer to Professor Vèzes, of Bordeaux, who has done much to improve the conditions of the industry in France, and the following information is taken from a *brochure* published by him in 1909. The French turpentine industry is confined to a triangular district called the "Landes," about 3½ million acres in extent, with Bordeaux as its principal town. About half this area, 1,750,000 acres, is forest planted with the maritime pine, and the yield of crude turpentine is about 100,000 tons annually. In the United States, forests of long-leaf pine (*P. palustris*) and of certain other varieties occupy a strip about 125 miles wide along the coast of the Atlantic and Gulf of Mexico, extending on both sides of Florida to Virginia in the north and Texas in the west. The forest districts represent about 70 million acres, a considerable portion of which has already been denuded by destructive exploitation. The annual production of the American forests is about 500,000 tons of crude turpentine. Until comparatively recently, these two countries were the only sources of resin products in the world, but small areas in other parts, notably Spain and Portugal, now account for possibly some 30,000 tons more.

The crude oleoresin, the "*gemme*" as it is called in the Landes, exudes in the warm season (from March to October) from an incision made in the trunk. Kept open by the removal of a thin slice every week, this incision—the "*carre*"—rises gradually up the trunk until it reaches, after five years' working, a height of four yards or so. The tree is then left to recover for two or three years, after which time a fresh *carre* is made at another point of the base. The tree is thus tapped for about forty years, after which it is "bled to death" (several *carres* being worked simultaneously) before being felled for lumber purposes. In the Landes district strict arrangements are carried out for replanting the forest, so that the resin production of the district is maintained. In the United States this conservative system has not been followed, it having been the custom to tap the trees "to death" from the beginning, and every plot which was subjected to tapping was practically destroyed after four years' working, without any systematic steps being taken to ensure its re-establishment. Recently, however, this wholesale denudation has attracted public attention, and a better system of exploitation may be expected to result.

From the top of the *carre* the drops of *gemme*, as they exude from the resin ducts of the tree, run down into a receiver. In France, in former times, and in America, until quite recently, the receiver was merely a hole hollowed out of the trunk at the base of the *carre*. The irrationality of this method has, however, been recognised, and the general procedure now is to hang an earthenware or metal pot below the point where the resin is exuding. The contents of the pots are transferred about once a month into casks which, when filled, are taken to the distilleries. There the *gemme* undergoes two processes: first, a fusion for the separation of the oleoresin from the water and dirt, and, secondly, a distillation in presence of steam for the manufacture of the two commercial products: volatile oil of turpentine and non-volatile resin (rosin or colophony). The relative proportions of products of Bordeaux turpentine are 20 % of oil, 70 % of resin, and 10 % of water and dirt.

Professor Vèzes has done much good work towards improving the quality of the products, not only in connection with the distillation, but also in connection with the collection of the crude material. It is recognised that the resin, both crude and in the course of manufacture, is a substance extremely sensitive to the oxidising action of air and sunlight. This action adversely affects both the colour of the product and its physical properties. A great improvement has been effected by reducing the period of exposure of the *gemme* during its stay in the incision, by raising the pot which receives the exudate at frequent intervals, so that the path traversed in its flow is as far as possible restricted, and by collecting the contents of the pots more frequently. By these alterations both the loss by evaporation of the oil and the colouration of the resin by oxidation are materially reduced.

Turning now to the conditions of the industry as it exists in the south of the U.S.A., some extremely valuable information is to be found in a paper by G. Walker on the utilisation of wood waste (*Jour. Soc. Chem. Ind.*, 1911, 934). According to this authority some 1½ million acres of virgin forest are destroyed annually after the trees have been tapped for turpentine over a period of four or five years. In the absence of organised lumbering arrangements most of the exhausted trees are left until they fall. The bark and sap-wood decay in from five to ten years, leaving a resinous heart, which is termed " light wood," because it burns with a luminous flame suitable for lighting purposes. This " light wood " is extremely rich in resin, sometimes containing as much as 40%, and it would appear that the resinous matter by some natural process concentrates in the heart of the tree after it is apparently dead. To some extent this " light wood " is utilised for the manufacture of gas, solvent oils and heavy oils by destructive distillation, but the author indicates that a far more rational method of exploiting it is to recover the valuable oil of turpentine and resin as such and to convert the residual wood into cellulose pulp.

The first portion of this double proposition is actually being carried out on a commercial scale at Conway, South Carolina, under the author's direction. The resinous " light wood," reduced to a fine state of division, is subjected to the action of live steam in steel cylinders for the distillation of the oil of turpentine and pine oil, and the residual wood is then treated with a volatile solvent for the extraction of the non-volatile resin. This apparatus is now producing resin at the rate of 200 barrels a week, and it is stated that five times as much resin and turpentine are obtained in twelve hours as are produced by the same amount of wood in four or five years by the tapping method. The author foresees, in conjunction with an organised system of forest conservation, the resin industry of the future worked in combination with the manufacture of wood pulp. The old wasteful system of tapping will die out, and the trees on reaching maturity (about twenty-five years' growth) will be felled full of resin.

In his projected scheme the author still appears to contemplate the rotting away of the exterior sap-wood in order to operate on the highly resinous " light wood," a process requiring five to ten years. There may be reasons, unstated, for this apparently wasteful complication, possibly connected with the expense of treating with solvents any but the richest portion of the trees ; that, however, is a detail which may be trusted to solve itself on its economic merits, taking into account the yield of cellulose to be obtained from the fresh sap-wood. The extraction of resin by volatile solvents and the manufacture of wood pulp, it is interesting to note, possess two technical features in common, viz., the necessity of first eliminating the coloured external layers of bark which would degrade the colour of the resin extracted by the solvent and contaminate the purity of the cellulose, and, secondly, the necessity of reducing the wood to chips of small dimensions before subjecting it to treatment.

Another worker in the same field, who has arrived at identical conclusions, is G. B. Frankforter, who has successfully carried out on an experimental scale the extraction of the oleoresin and the manufacture of cellulose from the same wood. An account of his work is given in the *Jour. Ind. and Eng. Chem.*, 1911, 3, 4—10. Two practical difficulties suggest themselves in the extraction of large quantities of a bulky material with hydrocarbon solvents as outlined by Walker. One is the difficulty of penetrating with the hydrocarbon a material which is already wetted in the preliminary steaming off of the volatile oil of turpentine by saturated steam. The other is the large amount of hydrocarbon solvent which must be carried through the apparatus and continuously re-distilled in performing the operation on an industrial scale. The first difficulty might conceivably be met by keeping the chips sufficiently dry during the distillation of the volatile oil by using superheated steam. Frankforter, however, adopts the method of taking out the volatile oil and the resin together by means of the solvent, leaving the treatment of the oleoresin for a subsequent operation. The solvent employed is petroleum spirit or coke-oven benzene, and the chips of resinous wood are charged into a battery of extraction vessels of sufficient size and strength to serve as digesters for the ultimate conversion of the exhausted chips into cellulose by the caustic soda or sulphate of soda process. The amount of solvent required for the extraction of the resin is very considerably curtailed by performing the extraction by means of the vapour of the hydrocarbon. Instead of filling the digesters with the liquid solvent as in the ordinary method of extraction, the hydrocarbon is first volatilised in a steam-heated boiler and the vapours only are passed through the chips, condensing on them and liquefying the oleoresin contained therein, so that it runs down into the still in the form of a concentrated solution. This modification must largely diminish the cost of the treatment and go far to bring it within the range of a practical industry. The subsequent operations are simple : the exhausted chips are steamed in order to recover the solvent remaining in them, and the caustic lye is then admitted into the same vessel, so that conversion into cellulose follows in the ordinary way by cooking under pressure without disturbing the charge of wood.

The waste of wood which takes place in the American resin forests, large though it is, is only a fraction of the total waste which takes place in connection with the whole lumber industry ; but the general problem of waste wood utilisation is considerably more complicated, and the prospective results of its solution are less obviously remunerative than in the case of the particular aspect here discussed. Enough has been said to indicate that with efficient organisation and scientific co-operation the stringent outlook for the world's supply of resin products might be considerably alleviated, and natural resources which are now being merely frittered away by methods excusable in a new territory might be developed in a spirit worthy of a great industrial nation.

SOME CONSIDERATIONS REGARDING LATEX FORMATION.

By CLAYTON BEADLE AND HENRY P. STEVENS, M.A., Ph.D., F.I.C.

(Continued from p. 261.)

THE variations in yield of latex for the years 1907—1911 inclusive from a certain property were 1·71 ; 2·44 ; 3·96 ; 4·13 ; and 2·66, showing a steady increase in yield with the age of the tree. The falling off last year (1911) was entirely due to the inclusion of a very large area of young trees brought into tapping for the first time. These figures are sufficient to show that 4 lbs. per tree per annum is a fair figure for trees of an average age. It is more difficult to obtain data for the average girth of such trees, and in some cases, no doubt, the bark is being removed at a greater rate than to allow of a four-year renewal, that is to say, to allow of the removal of the whole of the bark over the tapping area in four years. For our purpose we will, therefore, take a lower figure than that calculated above, and in place of a yield of 4 lbs. per 2½ sq. ft. of bark removed we will take the figure of 1 lb. of rubber per 1 sq. ft. of bark. This is certainly a very conservative estimate of yield. Now, a square foot of untapped bark off an average sized tree has a dry weight based on our own figures of about 6 ozs. Hence, if rubber and the other constituents of the latex be manufactured *in situ* as some contend, the cortex removed in a twelvemonth manufactures three times its weight of rubber or, if we suppose the latex drawn from the cortex to a height of about 15 ft. from the ground, we have this area of cortex manufacturing in one year its own weight of rubber. Of course a great part of the cortex represented by the bark is dead and only a very thin inner layer contains latex vessels in abundance; this inner layer may be taken as about one-third of the total thickness of bark and cortex. If the cortex be removed from the tree in large pieces we have found that most of the rubber is present in the outer dead layer cut off by the phellogen, and that the quantity contained in the latex vessels is very small indeed.

These data taken in conjunction with certain elemental chemical considerations, lead us to conclude that the latex is not formed *in situ*, but probably in the leaves; it may, however, undergo some change as it descends the tree. We find that latex drawn from the upper part of the trunk is richer than that from the lower in enzymes or in the oxyphenolic bodies in conjunction with which oxidation and darkening take place on exposure to air. We have also analysed the latex from the petioles of *Hevea* leaves.[1] Such latex differs chiefly in having a larger content of nitrogenous constituents. It is not difficult to picture the gradual descent of the latex down the tree from the leaves to the cortex undergoing some modification in the meantime. When a tree of average size is tapped over a bark area of 2 to 3 sq. ft. per annum, tapping every day, about 5 gms. of dry solids are removed. Let us attempt, if possible, to picture the formation of these solids *in situ*. The latex vessels are composed of a semi-permeable cellulose membrane, that is to say, a membrane permeable to water and also to salts and certain crystalloids held in solution, but impermeable to colloidal substances such as caoutchouc.

The latex which is contained in, or more correctly, issues from, these cells consists of an emulsion of caoutchouc globules and resin globules, or globules consisting of a mixture of both. In actual solution are various salts, chiefly potash salts, sugars, mainly l-methylinositol, and traces of nitrogenous substances. All these are diffusible through the cell walls. The greater part of the nitrogenous substances, the resin and the caoutchouc, are not diffusible and cannot pass through the cell walls. These form 95% of the total solids in *Hevea* latex. Now, the latex issues from the latex vessels when severed, so that it must somehow have found its way into them.

These are, however, impervious to caoutchouc, resin and the greater part of the nitrogenous constituents; these latter substances must have been actually formed in the latex vessels themselves from crystalloids, that is, diffusible substances which have passed in from without. Such a proposition at once leads to a number of conclusions which are not supported by any evidence, but rather the reverse. In the first place it is pertinent to inquire what are these crystalloids from which "protein," "resin," and caoutchouc are formed. The diffusible substances are present in the latex to the extent of 5% or less of the total solids; part of these are metallic salts, and the only other substance of importance consists of methylinositol, of which latex contains about 2 or 3%. This is the substance from which the caoutchouc, etc., is most probably formed, if formed at all, and the formation must be an extremely rapid one. There is no evidence to show that there is substantially more of this or any other crystalloid in latex from trees which are tapped at varying intervals, *e.g.*, twice a day or every day, as against those tapped every other day or every three days. We have examined a large number of latices on various occasions, but we have never noted any great variation in the relative proportions of the crystalloid and colloid constituents.

We should, moreover, have expected to find intermediate products, and that under certain conditions, the latex yielded only inferior rubber. The only cases met with are from very young trees (under three to four years of age), or from the branches, leaf petroles, etc., already referred to. We have never come across a single instance of cortex from the trunk of a mature tree yielding an inferior or semi-rubber-like product. We may also point out that methylinositol is not related chemically to caoutchouc. It is a fully saturated six-carbon ring derivative, and its conversion into an unsaturated eight-carbon ring, or indeed, any unsaturated body, is extremely unlikely from the chemical standpoint. It is found occurring naturally in many plants which do not possess any laticiferous system and which do not yield caoutchouc. There is a further consideration to which we first drew attention in this year's issue of the *Tropical Agriculturist.*[2] If caoutchouc, which is a hydrocarbon, be formed from carbohydrates, an elementary consideration from the chemical standpoint shows that this conversion can only take place with the production of large quantities of oxygen or carbon dioxide. A simple calculation shows that a typical carbohydrate would yield about half its weight of caoutchouc and half its weight of oxygen. This caoutchouc must be formed in the latex vessels and not outside them, as the caoutchouc cannot pass through the cell walls. This means that after tapping and removing the average 5 gms. of caoutchouc from the average tree, and during the next 24 hours, this amount of caoutchouc is manufactured *in the cells* with the production of 5 gms. or 3½ litres of oxygen. Is it possible to explain the escape of this volume of gas from the latex vessels? There is no highly oxidised substance in the latex which can account for its disappearance, and it can only pass out through the cell walls by solution in the aqueous cell contents in which it is but slightly soluble. It is well known that relatively large quantities of oxygen are dissolved in cell saps and circulate through the plant, but it is very difficult to understand how large quantities of oxygen can find sufficient liquid in which to dissolve and so pass out of the latex vessels in the course of a few hours. It must also be remembered that we are not dealing with the whole latex system of the tree, but only with the small area extending within a few inches of the tapping surfaces from which the latex is drawn. That this area is quite limited is easily shown by making incisions in the trees at various distances apart and noting the effect of one incision on the flow of latex from the adjoining ones. It is usually asserted that the cells are drained of latex for a distance of about 3 ins. from the point of incision. Hence the whole 3½ litres of oxygen must be disposed of by a system of latex vessels extending over a square foot or so of cortex. The figure 3½ litres is only an average one. It has been pointed out that the yields of individual trees at different periods vary enormously.

A single tree of average size will frequently yield 50 c.c. of latex, that is, say 20 gms. of dry rubber per day, for days at a time, which is four times the amount we have taken as an average figure, necessitating the liberation of 14 litres of oxygen per day. It would seem that such a large volume of oxygen could not be liberated in the course of a few hours, and if formed could only have the effect of bursting the vessels.

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[1] Beadle and Stevens. *The Analyst*, January, 1911.

[2] *Tropical Agriculturalist*, January, 1912, p. 4.

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We have shown that, in our opinion the latex probably descends into the latex vessels from those above, and these again are supplied with latex from higher up the tree till we eventually come to the leaves, where it is suggested the latex is primarily manufactured. If the latex has not been introduced into the severed latex vessels in this fashion it must have found its way in from the adjoining vessels *through the cell walls*. This, from the nature of the latex constituents and structure of the cells, we have shown to be impossible.

The only part of the plant where such changes as have been suggested could take place is in the leaves, which leads us back to the formation of caoutchouc there, and the gradual percolation down the laticiferous system of vessels until the tapping surface is reached.

Having considered the formation of the latex, and particularly the caoutchouc globules in the latex vessels, we are now faced by the equally difficult problem of determining how the plant makes use of the laticiferous system and the latex it contains.

Some of the theories put forward to explain the function of latex have already been enunciated. The evidence brought forward in favour of any particular view is seldom strong enough to exclude other interpretations. In sorting out such evidence it is probably safer to confine oneself to those who have written with first-hand information and who have based their views on their own observations. The botanist who first carefully investigated the formation and structure of the latex tubes of *Hevea* and *Manihot* was D. H. Scott.[1] These he described as "articulated vessels," formed by the breaking down of the transverse cell walls as distinguished from the "inarticulated cells" of many other *Euphorbiaceæ*. In a study of *Hevea* seedlings at various stages of growth he points to the early development of these laticiferous tubes which are well advanced as compared with the xylem of the bundles, and that the laticiferous tubes are formed on the phloem side of the bundles and at this early stage of development an extensive network of anastomosing tubes is produced. He further writes: "It is impossible to doubt that this tissue plays an important part in conveying the food substances derived from the endosperm through the cotyledons to the developing organs of the embryo. From this point of view its early development is quite intelligible, while the relatively backward condition of the xylem is explained by the fact that there are no demands upon its function as water-conducting tissue until the roots are able to take up water from the soil."

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[1] D. H. Scott, *Journ. of the Linnaean Soc.*, XXI. 566.

(*To be continued.*)

NOTES OF MEETINGS, &c.

INSTITUTE OF CHEMISTRY.

Mr. Edmund White, B.Sc., F.I.C., will deliver a lecture on "Thorium and its Compounds" on Friday. November 1st, 1912, at 8 p.m., in the Chemical Lecture Theatre of Finsbury Technical College, Professor Raphael Meldola, F.R.S., President, in the chair.

CHEMICAL SOCIETY.

November 7th and 21st, at 8.30 p.m.—Ordinary Meetings.

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SOCIETY OF PUBLIC ANALYSTS.

The next meeting of this Society will be held in the rooms of the Chemical Society, Burlington House, Piccadilly, W., on November 6th, at 8 p.m.

The following Papers will be read :—

> "The Detection and Estimation of Arachis Oil," by Norman Evers, B.Sc. "The Examination of Chinese and Japanese Wood Oil," by A. Chaston Chapman, F.I.C. "The Estimation of Manganese by the Bismuthate Method," by H. F. V. Little, A.R.C.S., B.Sc. The President will exhibit an apparatus for testing the purity of water by measurement of its electrical conductivity.

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SOCIETY OF CHEMICAL INDUSTRY.

London Section :—The next meeting of this section will be held at the Chemical Society Rooms, Burlington House, on Monday, November 4th, at 8 p.m., when the following Papers will be read and discussed :—

> "The Nitrogenous Constitution of Para Rubber and its bearing on the nature of Synthetic Rubber," by Clayton Beadle and H. P. Stevens. "The Corrosion of Metals and Alloys in various Solvents," by A. J. Hale. "The Viscosity of Lubricating Oils," by A. E. Dunstan and J. F. Strevens.

Newcastle Section.—The Committee, with the Authorities of Armstrong College, have arranged for the delivery of lectures on "Some Modern Developments of Applied Chemistry" during the coming Winter Session. The scheme formulated by a joint Committee of representatives of the Council of Armstrong College and the Committee of the Section, has received liberal support from several of the principal firms in the district, and the following courses of Evening Lectures have been arranged :—

1. "Coal Gas Manufacture, etc.," by Dr. H. G. Colman—Five Lectures, on Wednesdays, October 16th and 30th, November 13th and 27th, and December 11th, 1912.
2. "Metallography," by Dr. C. H. Desch—Five Lectures on Tuesdays, January 28th, February 11th and 25th, and March 11th and 18th, 1913.

Further particulars and tickets for the courses can be obtained from Mr. F. H. Pruen, M.A., Secretary, Armstrong College, Newcastle-on-Tyne.

UNIVERSITIES AND COLLEGES.

THE CITY AND GUILDS OF LONDON TECHNICAL COLLEGE, FINSBURY:

Past and Present.

BY F. W. STREATFEILD, F.I.C., SENIOR DEMONSTRATOR IN THE CHEMICAL DEPARTMENT.

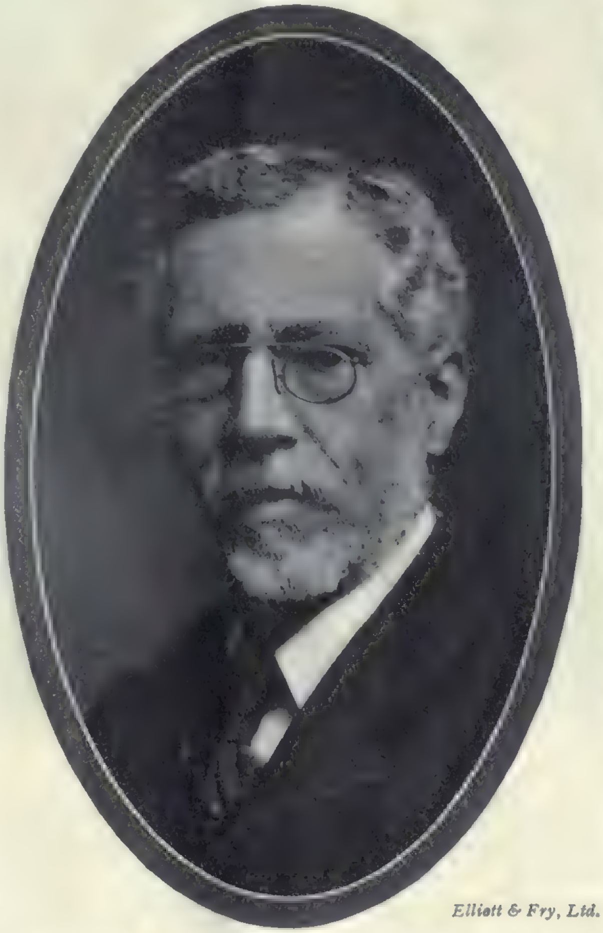
THE City and Guilds of London Institute, of which the above College is a branch, was founded in 1878, incorporated under the Companies Acts in 1880, and received the grant of a Royal Charter in 1900. It is an association of the Corporation and Livery Companies of the City of London.

During the building of the Finsbury College, work was started in the Old Cowper Street School, City Road, and the chemical department commenced operations in a top room of the school.

This was in 1879. Dr. H. E. Armstrong was the Professor of Chemistry, and, assisted by the late J. Castell-Evans, pioneer work was done in the cause of technical education. Classes were held in the daytime and during certain evenings in the week, and were attended by young men and women anxious to study chemistry in its relation or application to some particular industry.

It is important to bear this in mind, because, hitherto, science classes in London were attended almost solely with the view of passing the May examinations of the Science and Art Department, South Kensington, and with the attendant necessity of "keeping to the syllabus."

Some time about 1883, the work was transferred to the new premises in Leonard Street, City Road, and regular day and evening courses started. Day classes for those who were able to devote one, two, or three years to systematic technical instruction, and evening classes for those who were engaged in industrial or commercial pursuits in the daytime and who desired to receive supplementary instruction in the trades, or manufactures, in which they were engaged.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PROFESSOR RAPHAEL MELDOLA, D.Sc., LL.D., F.R.S.

As was to be expected in pioneer work of this kind, so different from preparing for examinations, a certain number of "odd" students were attracted, especially to the evening classes, and the writer, who joined the Chemical Staff in 1883, recollects some rather amusing instances which he may here briefly describe: One man wished to study chemistry in order to devise some new and startling chemical tricks which could be put up in boxes and sold for one penny! Another student wished to study organic chemistry with the view of finding some cheap substitute for rubber and naïvely informed the writer that he was prepared to pay a *little* more than the College fee for a *really* good substitute. But the majority of the evening students in the chemical department were really earnest workers who were desirous of obtaining a good knowledge of the scientific principles underlying their work, and some came from such distant places as Brighton and Peterborough, returning by a late train.

In the early days of the College there were trade classes, but this work has been transferred to other institutions.

In addition to the chemical department the College has excellently equipped mechanical and electrical departments, "with the special aim of giving scientific instruction both to those who have not yet had and to those who have already had experience in engineering shops or factories as apprentices or pupils." These students receive theoretical and practical instruction in chemistry at stated times in the week.

In 1885 Professor Armstrong left the Finsbury College to take up his duties as Professor of Chemistry at the Central Technical College, South Kensington, and Professor Raphael Meldola, D.Sc., LL.D., F.R.S., was appointed Professor at Finsbury.

The chemical students enter for a two or three years course, usually the latter, but some return for a fourth year. The instruction "is specially arranged with the object of imparting such knowledge of the principles and practice of Chemistry that lads of average ability should be able after three years' study in the College to carry on operations involving applications of Chemistry with intelligence." The students are trained in the principles of analysis and the preparation of chemicals on as large a scale as possible, so as to prepare them to "think in tons," when the proper time arrives.

"This is the only Technical College of its standing which definitely refuses to spend its energies upon preparing its students for any outside examinations. It strictly adheres to the aim of training students directly for the industries or professions, mechanical, electrical or chemical, which they propose to enter."

I believe it can be safely asserted that during the thirty-odd years that the chemical department has been at work its success has been very pronounced. Many of its past students occupy important positions in academic and industrial fields. For instance, Professors Pope, Forster, Morgan, Desch and Campion, are engaged in teaching, and Messrs. Droop-Richmond, Coste, J. L. Baker, engaged in analytical and industrial work were former students at Finsbury. Many others are doing excellent work in Great Britain and abroad. It is interesting to find that in a College which does not profess to prepare for any outside examination, that a large proportion of its past students are graduates of the London University, or Fellows of the Institute of Chemistry. All this indicates the strenuous life. Many of the students when they leave Finsbury proceed to Germany and return with a doctor's degree. It is satisfactory to relate that our students find the training received at Finsbury very helpful in a German laboratory; in fact, in many instances surprise has been expressed at their grasp of practical detail.

Chief Chemical Laboratory. North Side.

In 1908 a large addition was made to the College buildings; splendidly equipped mechanical and electrical laboratories have been built, containing all the latest and most up-to-date machinery and apparatus.

The art department has been accommodated with modern studios, but the chemical department has so far not been enlarged.

The older portion of the College is built of a very superior hard grey brick, and the interior of the building, class rooms and laboratories, still present the original brick surface.

In the early days of the College, the naked well-pointed brickwork was rather impressive, but it must be confessed that the pristine freshness has long since departed. A visitor to the College once rather deprecatingly remarked to the Principal, Dr. Thompson, that the place reminded him of a factory and the Doctor thanked him for the compliment! This factory-like appearance is characteristic of the whole College. It is a place where *practical work* is done, some of it of rather a rough nature.

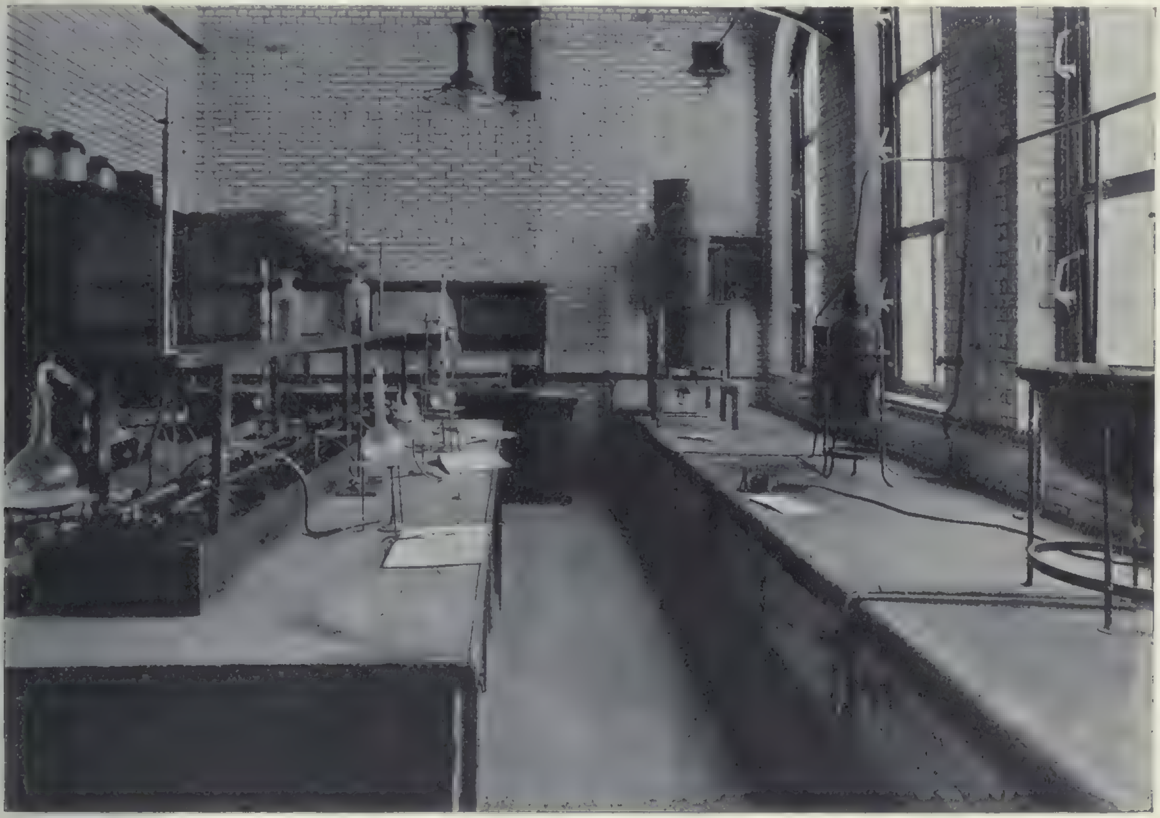
The chief chemical laboratory is a large lofty room (about 60 feet square). The floor is asphalted. There are the usual fume-cupboards, steam-evaporators and ovens. The laboratory is heated in the winter by hot-water pipes. On stone tables are furnaces for combustion and assay work. A Blackman air-propeller fan, worked by an electric motor, which is used to remove fumes from the steam-evaporator, assists in keeping the air pure.

The laboratory is capable of accommodating about eighty students, and here, from 9.30 a.m. on Monday till 5.0 p.m. on Friday, men will be found at work. All first, second and third year students work in this laboratory and on Tuesdays and Fridays students from the mechanical and electrical departments attend for practical work. Evening students also use this laboratory, the benches being so arranged that separate cupboards, drawers and reagents are available for them. The work carried on here is very varied—qualitative and quantitative inorganic and organic analysis and preparation of compounds, the larger scale work being carried on in another laboratory, the "chemical operations room."

In a laboratory which is used for such general work it is a common experience for a demonstrator to reply in rapid succession to questions ranging from the preparation of hydrogen, the constitution of indigo and the best way of dealing with the assay of a refractory ore

The balance room adjoins the main laboratory, and is well supplied with balances arranged for different grades of students, and includes an assay balance. The balance room is also used as a library and contains works of reference. The Students' Chemical Society display in this room the current chemical literature.

It will be noticed that the balances are supported on shelves fixed by iron brackets against the walls, and as these walls are very thick and substantially built, very little vibration is experienced. This is an important matter in a neighbourhood such as this, where there is heavy street traffic.



CHEMICAL OPERATIONS ROOM.

Room 29, as it is numbered, is used for gas analysis, optical work, and just recently a small electro-chemical plant has been introduced, and here small batches of more advanced students work during part of their course.

Another laboratory called the "chemical operations room," or Room 7, may next be described. It is a large room, lofty and well lighted, lined with white glazed tiles, with plenty of bench accommodation large fume-cupboards, etc. There is satisfactory water pressure, and the floor is of such a nature that a "spill" can easily be washed up. Steam is "laid on." It is furnished with steam-jacketed pans and a copper still and condenser. Power is available.

This laboratory is used for the preparation of chemicals on a larger scale than can be attempted in the general laboratory. It is here we keep the "cannon," used for heating sealed tubes, and an occasional *bang* behind a warning board, indicates only too surely that another experiment has gone beyond recall.

Coal-tar distillation is carried on in this room, and thanks to the Beckton Ammonia and Tar Works, we have been well supplied with crude gas tar for our experimental distillations. The tar is distilled from small iron retorts and the chief products worked up and valued. Some few years ago much experimental brewing of beer was conducted in this room. Dr. Moritz presented the College with a small experimental brewing plant, and some of the students who were interested in brewing and fermentation derived much valuable experience from this work, and although the opinion of "experts" is not always flattering on the quality of the "beer," yet many of the past students who are now acknowledged experts, have gained valuable information in Room 7.

Some time is devoted to the production of alcohol, and for this we are indebted to Messrs. Truman, Hanbury and Buxton, for a supply of malt for our experimental brews. Another typical operation is the preparation on a fairly large scale of pure barium chloride from Witherite.

Evening students may work in this room, and some past evening students have availed themselves of the conveniences of this laboratory to try experiments on a small commercial scale.

In such a laboratory as this a lot of really useful work can be done and on a larger scale than is possible in a general laboratory; the students become familiar with the use of steam-pans and stills and certain "dodges" connected with filtration, evaporation, etc. This laboratory is on the ground floor of the building, and possesses many decided advantages in this position.

Balance Room and Reference Library.

Passing through the Professor's private room—in this room there are two excellent research balances—we find the research laboratory. This is a well-lighted room, 20 by 20 feet square. It has three excellent benches with Indian teak tops (these are kept well preserved by an occasional rub down with a little boiled linseed oil.) On a stone bench under a hood are the combustion furnaces. It has three good draught fume-cupboards, a medium sized burner in a flue generating sufficient draught for most purposes.

In this laboratory three or four persons can work comfortably, and the writer of these notes remembers with pleasure when he worked here, first, with Professor H. E. Armstrong, and later with Professor R. Meldola. The students who worked with us were those who had passed through the usual chemical course and who wished to gain experience in methods of research.

The students who now assist Professor Meldola are generally third year certificated men who show aptitude for this kind of work, and it is from this little *workroom* so many papers have emanated that have found publication in the Journal of the Chemical Society.

Every year we find certain students, possessing initiative ability, men who can *think*, excellent material for training in research work, and moreover are anxious to continue their scientific studies, but who are compelled, from lack of funds, to seek a situation. In some cases a scholarship has "come to the rescue" and enabled a promising student to continue his studies.

At the end of every session two senior students or student assistants are appointed to assist the staff in teaching at certain stated times, and when not thus engaged, these men can devote themselves to research work, to special work of a technical character, or to qualify themselves for some examination such as the Institute of Chemistry or the London University. A small honorarium is given by the City Guilds to assist them while at the College.

There is a commodious chemical lecture room capable of seating over a hundred students, and connected with this is a large lecture-preparation room. A small class room on the same floor as the main laboratory is fitted up for experimentally illustrating lectures, most of the advanced courses to small classes being given in this room.

THE ALLOTROPY OF TIN: "TIN-PEST."

By T. MARTIN LOWRY, D.Sc. (LOND.), F.C.S.

The Decay of Tin.—Although the decay of metallic tin has been known from classical times, the exact study of the phenomenon has been carried out almost exclusively during the past thirteen years by Professor Ernst Cohen of Utrecht.[1] The crumbling of the metal takes place at low temperatures and is obviously the phenomenon referred to by Aristotle in the following passage: "They say that Celtic tin melts much more easily than lead . . . It melts also in the cold, when there is frost, because, it is said, the warmth which is in the tin is imprisoned in the interior and compressed owing to its weakness." In modern times it has been observed by Erdmann in Germany, by Fritzsche in Russia, and by Cohen in Holland and elsewhere. The nature of the phenomenon, as observed in blocks of pure Banca-tin, is very clearly described by Fritzsche, who found that "whilst some blocks had remained entirely unchanged, others had undergone a more or less radical alteration . . . The completely changed blocks had partly turned into a grainy powdered mass like sand; other portions formed lumps of various dimensions up to the size of a fist, of loose cohesion and fibrous texture. In specimens which had been exposed to artificial cold, the effect of the cold had apparently started from certain spots and had spread, developing warty growths and a coarse fibrous structure. Where two such centres met, fissures were formed along the boundary, suggesting a rough mosaic structure; the material could easily be separated at these fissures."

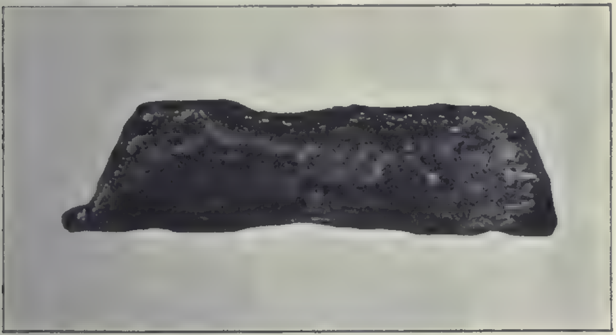


FIG. 1.—DECAYED INGOT OF BANCA-TIN.

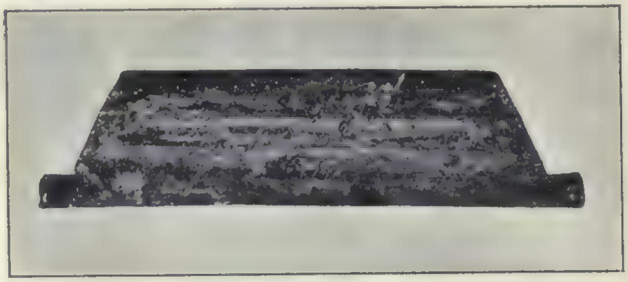


FIG. .—ORIGINAL INGOT WEIGHING 35 KILOS.

The extent to which the metal may decay is shown by the appearance of an ingot (Fig. 1) now in the possession of Professor Cohen, which was returned to Rotterdam by a Moscow firm, because adulteration was suspected; actually, the metal contained not more than 0·05 % of impurities. The block originally weighed 35 kilos., and was similar to that shown in Fig. 2, but had already lost several kilograms, and grey powder was still dropping from the block.

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[1] *Zeit. physikal Chem.*, 1899, *30*, 601; 1900, *33*, 57; 1900, *35*, 588; 1901, *36*, 513; 1904, *48*, 243; 1904, *50*, 225. I am indebted to Prof. Cohen for permission to reproduce the illustrations from his recent lecture to the Faraday Society (Trans. Faraday Soc., 1911, *7*, 122—135).

"Grey Tin" and "White Tin."—The colour of the modified tin is decidedly grey and distinctly different from that of the ordinary bright metal. When the tin is heated, this colour undergoes a very striking change; the dark grey colour becomes much lighter, almost like that of ordinary tin; this change takes place when hot water is poured on the metal, or when the metal is heated in a stoppered bottle on a water bath (Fritzsche).

The grey tin is much lighter than the white form of the metal. The relative densities at 18° C. are given by Cohen as:—

White tin ..	7·28
Grey tin ..	5·79

The conversion of white into grey tin is therefore accompanied by an expansion of 26 % in its volume, causing the new variety to swell up in warty patches, and ultimately compelling a complete disintegration of the metal. The contraction which accompanies the converse change from grey to white tin when heated by hot water is complete in the course of a minute or so and forms the basis of a very striking lecture experiment.

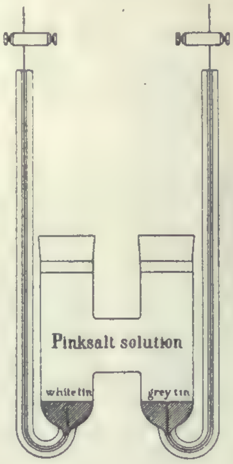


FIG. 3.

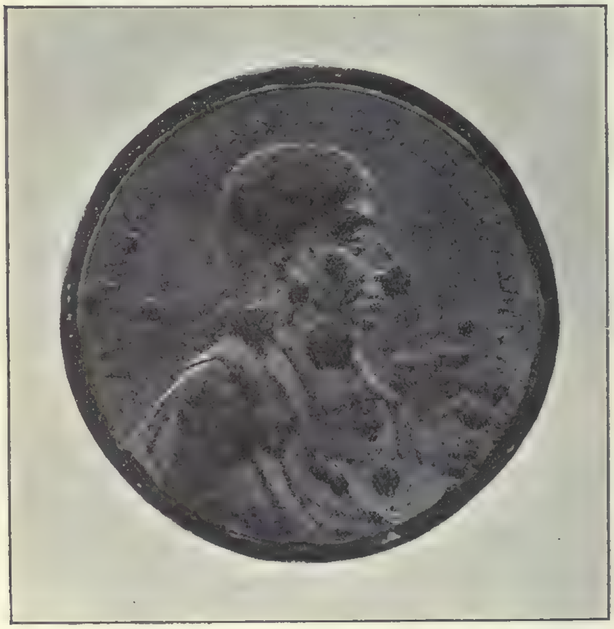


FIG. 4.—TIN MEDAL CAST IN 1692, SHOWING INFECTION.

Transition Temperature for Grey and White Tin.—The conversion of white into grey tin by cold and of grey tin into white by warming is a reversible action of the same general character as the interconversion of prismatic and rhombic sulphur. But the change proceeds so slowly, and there is so much lagging that a special method had to be devised for determining the transition temperature. This consisted in constructing a cell in which the two forms of tin acted as electrodes in a solution of ammonium stannic chloride (Fig. 3). It was found that above 18° C. current flowed from the grey tin through the solution to the white tin, in such a way that grey tin was dissolved and white tin deposited; below 18° C. the direction of the current was reversed, white tin

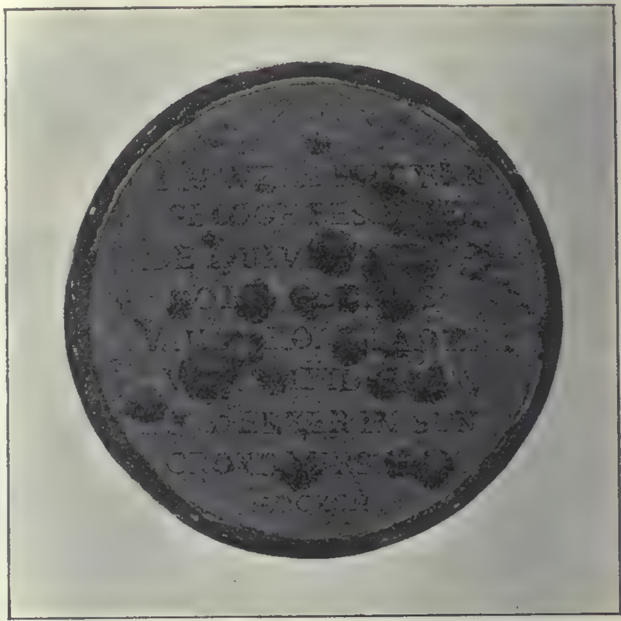


FIG. 5.—TIN MEDAL CAST IN 1692, SHOWING INFECTION.

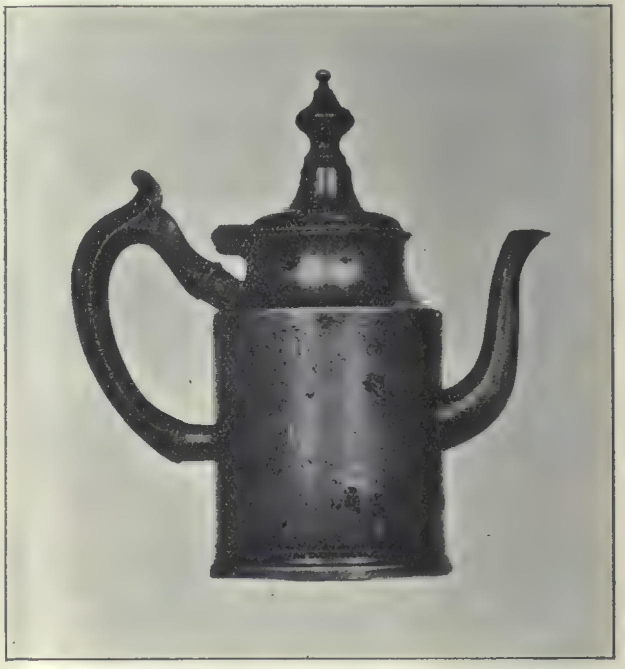


FIG. 6.—ANTIQUE COFFEE-POT, SHOWING "TIN-PEST."

being dissolved and grey tin deposited. The direction of the E.M.F. being reversed at 18° C., this was evidently the transition temperature.

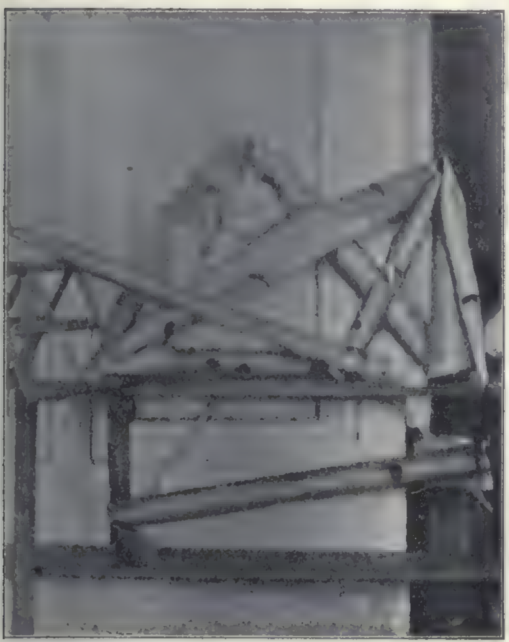


FIG. 7.—ORGAN PIPES FROM SILESIA, SHOWING DECAY, CAUSED BY TIN-PEST.

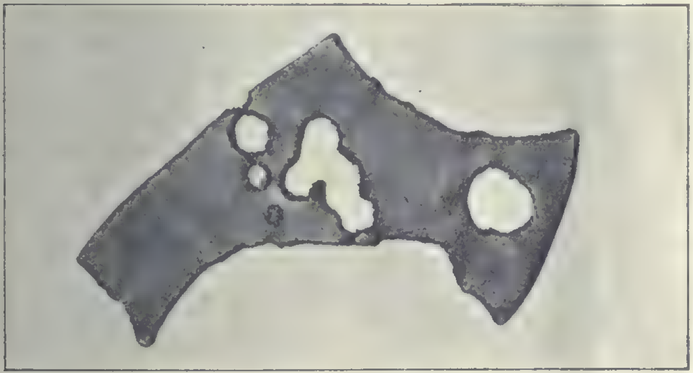


FIG. 8.—HOLES IN ORGAN PIPES.

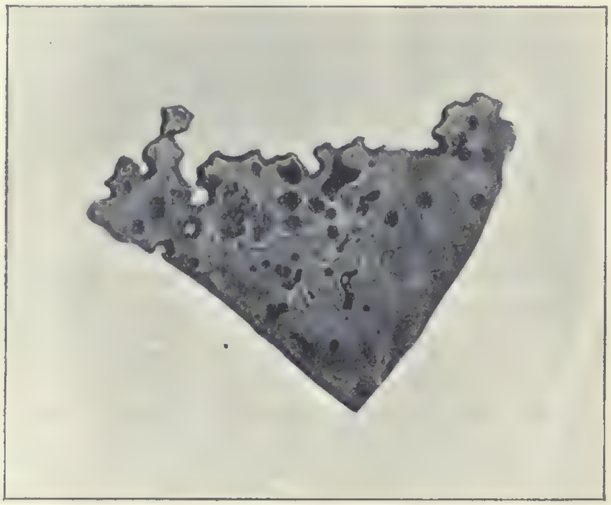


FIG. 9.—SHOWING INFECTION OF A ROOF AT ROTHENBURG.

White Tin a Metastable Form.—As the atmospheric temperature is usually below 18° C., it follows that during the greater part of the year practically the whole of the white tin in Northern Europe is metastable, tending constantly to pass into the grey form, which alone is stable below 18° C. The change is, however, very slow, unless the metal be specially cold, the velocity of transformation reaching a maximum at 45° C. (Cohen). All the earliest observations of "tin-pest" were, therefore, made during specially severe winters. Erdmann records the crumbling of block-tin organ pipes in Saxony; Fritzsche recalls a military scandal, when a large stock of military buttons, supplied by a Russian contractor, were found on inspection to have decayed into a shapeless mass; he also describes the experiences of several Russian merchants who had suffered loss during the winter of 1867—1868, when the temperature at St. Petersburg had fallen to 38° C.; Cohen's stock of grey tin was also derived from a similar source. But when sufficient time is allowed the change may manifest itself at temperatures well above the freezing point; "tin-pest" is in fact a museum disease, which may be transmitted from one tin object to another and can only be held in check effectively by maintaining a temperature steadily above 18°. Cohen quotes the case of an antique tin dish, found near Appleshaw in Hampshire in 1897, and now stored in the British Museum, which had become so exceedingly brittle that it could easily be broken with the fingers. Coins accompanying the vessel indicated a date about 350 A.D., thus allowing a period of 1550 years for the "pest" to develop. Figs. 4 and 5 show the appearance of a tin medal cast in the year 1692 by a Leyden medal maker; warts of grey tin (even more disfiguring than that which adorned the features of Oliver Cromwell) have made their appearance on both sides of the medal and have grown to a height of several millimetres. Fig. 6 shows an antique coffee-pot in which "tin-pest" has resulted in an actual perforation of the metal.

"Tin-pest" Infection.—The production of grey tin is promoted by cooling, by vibration (as in the case of the organ pipes of Figs. 7 and 8), but above all by inoculation; these methods may with advantage be combined when it is desired to produce grey tin artifically. Stockmeier recorded in 1893 that the cast-tin roof of the post-office at Rothenburg in Germany had been attacked by tin-pest following upon severe weather, and was corroded in many places, whilst the rolled-tin roof of the adjacent town-hall was completely intact. Some years later, however, the roof of the town-hall was found to have become infected; the result is seen in Fig. 9.

THE ELECTRO-CHEMICAL PRODUCTION OF OZONE.

By Eric K. Rideal.

Great attention is being paid at the present time to the theory of the production of ozone, since this allotrope of oxygen is playing an ever-increasing *rôle* in daily life. It is in use for the purification of air and water in large quantities and to a less extent in the defecation of sugar, the preservation of meat, bleaching, and in many synthetical chemical processes, such as the oxidation of iso-eugenol in the production of artificial vanillin; in the research laboratory it is an all-important substance for the investigation of sugars, rubbers, and many other compounds. Apart from the formation of ozone in small quantities in the so-called autoxidation phenomena such as are exhibited by phosphorus, turpentine, and certain algæ when exposed to the air in the laboratory, the pine forest and the filter bed, all ozone is made electrically and even these processes of autoxidation are thought by many to be of a purely electrical character. From the heat of formation of ozone from oxygen it is found that whilst 1·2 kilos. of oxygen can be converted into ozone by the expenditure of one kilowatt-hour, the best yield ever obtained in practice is 36·7 gm. per kilowatt-hour; this is a sufficient indication that the "last word" in ozone production by means of scientifically designed apparatus has not yet been arrived at. A definite equilibrium exists between the oxygen and the normal ozone content of the atmosphere; the quantity of the latter, however, at normal temperatures is generally undetectable. The velocity of transformation of ozone into oxygen at these temperatures is very small; hence there is a possibility of obtaining an apparently stable, yet actually unstable system with an artifically high ozone content. Nernst has calculated the equilibrium mixtures at high temperatures, and found that at 4,500° C. 90% of oxygen is in equilibrium with 10% of ozone, while at 1,300° C. 0·1% of ozone only is present. Since the velocity of transformation rises with the temperature, some arrangement for the rapid cooling of the ozonised oxygen or air must be used in order to obtain the artificially high ozone content. Clement in 1904 produced ozone by immersing a Nernst electric filament in liquid air. Fischer in 1906 obtained air containing 0·03% of ozone by driving a stream against a glowing Nernst filament at 60 metres per second. Another method for the production of ozone, is based on the effects of electrolysis on dilute aqueous sulphuric acid or potassium perchlorate solution. The anodic potential necessary for the liberation of oxygen is 1·08 volts—for ozone 1·67 volts; consequently a high anode potential and high current densities are requisite for the liberation of the oxygen in the form of ozone. Fischer (*Zeit. f. Anorg. Chem.*, 1907), by the electrolysis method, using as anode platinum embedded in glass (thus ensuring a very small anodic area), obtained 22% of the anodic gas in the form of ozone. This, however, was only equivalent to 7 gms., of the ozone per kilowatt-hour.

Neither of these two processes yield amounts of ozone that give the methods anything more than theoretic significance; for the active ozonising influences, namely, the area of production of heat in the first case, and the area of liberation of oxygen ions at high velocity in the second case, are both too restricted to be of any practical value.

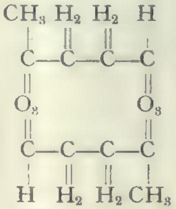
The best and the oldest method of producing ozone is by means of the silent electric discharge. This kind of discharge takes place when two large (solid or liquid) conductors, separated by a badly conducting dielectric space, are made the poles of a high potential machine; when a heavy discharge is taking place this space is filled with a faint bluish flickering light, no sparking or "arcing" taking place across the dielectric. When a current of air is sent through this feebly luminous space a certain quantity of the oxygen is converted into ozone. The following is a brief summary of the conditions obtaining for the maximum yield. Ewell (*Phil. Trans.*, 1906) found that, when the electrodes were covered with another dielectric besides air, such as glass or mica, the yield of ozone was increased; this was probably due to the diminution of the minute sparks that occur on the surfaces of the electrodes and thermally hasten the decomposition of the ozone already present.

The most efficient current to use seems to be an alternating one of a periodicity lying between 200 and 500 volts. The voltage should be as high as possible, but is limited by the consequent rise in temperature and by the increased tendency for sparks to bridge across the inter-electrodic space. The rate of formation of ozone is retarded by the presence of moisture and by any ozone that may be present; the presence of 1 c.c. of nitrous oxide in 1,500 c.c. of gas prohibits the formation of any ozone, this latter phenomenon being a rather interesting case of gaseous poisoning or negative catalysis. Oxides of nitrogen are generally produced by sparks getting across the dielectric or due to traces of moisture in the air passing through the ozoniser.

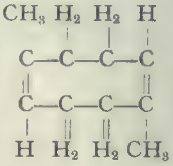
As has already been stated the electrodes and inter-electrodic space require cooling in order to preserve the artificially generated ozone from decomposing. This is a point which is overlooked in a good many of the so-called practical ozonisers of the present day.

Regener (*Ann. der Physik*, 1906) has shown that ultra-violet light has an ozonising effect on oxygen until a definite concentration of ozone is reached (about 2%); then a de-ozonising influence makes itself apparent. Since in the silent discharge a certain amount of ultra-violet light is always formed one of the sources of inefficiency can be attributed to this cause.

The theory of the formation of ozone is at present unsolved; partly, no doubt, due to the fact that the molecular structure of ozone is not sufficiently well determined, since not only does ozone oxidise by the liberation of a "nascent" oxygen atom, indicating that one atom is asymmetrically situated in the molecule, but it will also form compounds such as the rubber-forming ozonides. The following formula represents such an ozonide:—



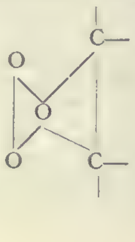
derived from



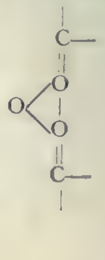
one of the commonest rubbers

by the action of very dilute ozone.

At present the mode of linking of the ozone nuclei in the molecule is unknown, different authorities favouring different structures. Among these may be mentioned:—



and



NOTES ON CHEMICAL RESEARCH.

By THE EDITOR.

CHAPTER VII.—(*Continued*).

THE third method of direct publication is in the form of a monograph, treatise, book, or pamphlet. This is the method least often adopted in this country, owing to the question of personal expense and distribution.

Protection by Patent.—Closely connected with the question of publication is that of protection by letters patent. This only applies to a matter which has an industrial application, as an abstract idea cannot be protected. The only recognition for work of a theoretical nature is by publication.

The question of publication by patent under which the State grants a monopoly of user under certain defined conditions is one which must be decided in consultation with a patent agent. A provisional protection may be granted for six or seven months in this country for a nominal sum, and this does not entail publication, if the patent is not completed.

It may be advisable in certain cases to apply in the first instance for the German patent. It will be remembered that a special technical commission in that country examines all patents for novelty and previous publication. In this country the search is confined to English patents for the last fifty years.

The stage at which a patent should be taken out is a matter which demands close attention. If protection is obtained before the details have been worked out sufficiently for the process to be a workable one, its value is correspondingly small. In this respect the English Patent Office offers certain advantages by granting provisional protection. During the subsequent period of six months, the detail of the invention may be embodied by a final specification.

In modern practice it may happen that only part of the invention is actually patented and certain details remain secret. This is a matter which naturally demands special knowledge and involves questions of general policy.

The value of such rights to the investigator is difficult to determine. This may depend upon other considerations than that of the importance of the research. Utility is a matter of chief concern, and is a necessary qualification from the legal standpoint.

Facility for Research in this Country.—It has been held in the past, that this has not been generally available, and it may be argued that this has been a correct assumption. Many of the provincial universities, however, now advertise facilities for research, and the Royal Society and the Chemical Society have at their disposal limited funds which they disburse by way of grants, prizes, scholarships, etc. Research is also conducted at such institutions as the National Physical Laboratory, the Royal Institution, and certain other research stations.

Some of the scientific and technical societies form committees to determine certain points by investigation. For instance, the Institute of Gas Engineers has appointed a Gas Heating Committee, which reports from time to time (see *J. Gas Lighting*, 1910, *2*, 810), and the Institute of Metals is dealing with the corrosion of metals in a similar way.

The Government offices also from time to time appoint committees to deal with points which more or less involve chemical investigation (see *Times Eng. Sup.*, September 21st, 1910). The publications of the Bureau of Mines at Washington, U.S.A., dealing with technical researches and progress are also of considerable importance.

Some of the more modern universities, as, for example, that of Sheffield (*Times Eng. Sup.*, October 26th, 1910) deal in a similar manner with investigation of more or less technical importance. Thus in the case mentioned the Applied Science Committee has arranged that any new processes brought forward may be tested in the University on a manufacturing scale before any number of manufacturers adopt it. When, therefore, the general question is asked, whether it is advisable for the student or general chemist to engage in research, the answer must depend upon certain conditions which cover his training and knowledge of chemistry, natural adaptability, and facility for engaging in such work. The opportunity and time for conducting or engaging in such investigation may generally be met even when the operator is engaged in practical work.

The beginner must determine how far he is able to conform to certain necessary conditions before attempting such work. Given favourable conditions, much will depend upon the nature of the proposed investigation. In some cases the chances of success are possibly more satisfactory when carried out in one of the recognised colleges, but (according to Gore) only if the professor is an initiator, and can carry on such work, and if he actually engages in the same with the student.

On the other hand it is certain that there are many successful investigators who have not worked under these conditions, and evidence can be advanced which indicates that in the majority of cases, industrial research can hardly be expected to originate in the college itself. It so often happens that it owes its origin to observation made under practical working conditions.

In many cases, as in the electro-chemical and several other modern industries which owe their existence to research, investigation has been carried on by certain industrial organisations on a scale which could not have been undertaken under our present college system. The results obtained have been of the greatest possible advantage to theory, as well as practice. Such laboratories are said to be in every way equal, and in some cases even superior, to those of the colleges and universities.

This relative value of research conducted under such different conditions is difficult to decide. This can only be settled by a more thorough investigation into the subject than can be undertaken on the present occasion. Conditions are rapidly changing in our colleges, and to this extent the position is being correspondingly modified.

Considering the amount of research that is carried out by independent investigators, the condition that it must be carried out in the college or university has not been proved to be essential. At the same time there is much research which requires the aid of complicated apparatus. For this, and other reasons, it may be best carried out at such institutions, but a certain section of it must remain outside the range of the college requirements or programme and altogether beyond their financial means. It may, therefore, be necessary at some future time to reconsider the available facilities offered for such research work in the institutions of this country, and to determine their natural limitations and scope, and possibly to secure conditions of working which will facilitate a further advance in the required direction. It is possible that the time has not yet arrived when such a step can be taken with any degree of certainty. That this time will come in the natural development of scientific investigation is fairly certain. In the meantime it may be remembered that an extraordinary advance has taken place during the last decade in this country in the facilities for research.

Japanese Peppermint Oil Industry.—Japanese peppermint is remarkable for the large proportion of menthol crystals it contains. The dementholised peppermint oil of Japan is disagreeable in taste and odour and cannot compare with that of other countries, but owing to the large percentage of crystallisable menthol contained in the raw oil the product is nevertheless a valuable one and the export considerable.

The trade is remarkable for its fluctuations. The exports of menthol in 1911 amounted to 151,538 lbs., valued at £98,300, and of peppermint oil to 229,800 lbs., valued at £63,900. The best oil is produced in Okayama and Hiroshima Prefectures, where three crops are obtained, *viz.*, in May, June and August. The first crop contains about 47 % of crystals, the second about 53 %, and the third about 60 %.

The process of distilling the oil lasts four hours, and 82 lbs. of dried leaves of the first crop should produce 14 ozs. of oil, of the second crop 24 ozs., and of the third crop 21 ozs. of oil. These figures of course vary, depending on the quality of the leaves and the extent to which they are dried. The second crop is the most plentiful—a field, for instance, which will produce 300 lbs. of leaves for its first crop, will give 800 lbs. for the second, and 600 lbs. for the third.—*Board of Trade Journal.*

EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

THE inaugural meeting of this Congress took place at Washington on September 4th in the Memorial Continental Hall. In the unavoidable absence of the President of the United States, the chair was taken by the President of the Congress, D. W. H. Nichols. Speeches of welcome were delivered by the Chairman and also by the Honorary President, Professor E. W. Morley, and responded to by the delegates of the principal nationalities represented at the meeting. Sir William Ramsay, K.C.B., F.R.S., replied on behalf of Great Britain. The members and delegates were invited to a garden party at White House by President Taft, who, in spite of a slight indisposition, gave an address of welcome and subsequently shook hands with many of the visitors.

The following day some of the delegates made a trip to George Washington's old home at Mount Vernon, whilst others visited certain government institutions, special attention being given to the U.S. Department of Agriculture, the U.S. Bureau of Standards, the U.S. Bureau of Mines, the U.S. Geological Survey and the Geophysical Laboratory of the Carnegie Institution. Visits were also made to the Capitol and Library of Congress.

The business and scientific meetings commenced in New York on September 6th. Convenient lecture rooms were placed at the disposal of the Congress by the authorities of Columbia University, who also opened their refectories and halls of residence for the accommodation of visiting members. The scientific work was divided into twenty-four sections, and in addition four lectures of general interest were delivered in the Great Hall of the College of the City of New York by eminent delegates representing France, Germany, Great Britain and Italy. Scientific communications to the Congress received on or before June 30th had been already printed and were ready for distribution to the members on September 3rd in twenty-four volumes containing more than 550 papers. The discussions taking place at the sectional meetings were recorded phonographically on instruments specially devised for the purpose by Mr. Edison.

SECTIONAL MEETINGS.

In the analytical section several reports were presented on the standardisation of methods of analysis, notably one on the standardisation of methods of determining water in coal and in other fuels and in minerals drawn up by G. T. Holloway. The methods of the U.S. Steel Corporation for the commercial sampling and analysis of pig iron were brought forward by the Chemists' Committee of this Corporation. Professor Lindet, a past president, presented a report from the International Committee on analysis. Several papers dealt with the estimation of sulphur in fuels and illuminants, and two communications with the analysis of nitrates by reduction processes.

The sections of inorganic chemistry and silicate industries held a joint meeting to consider the various natural sources of potash. An experimental lecture on the element boron, its compounds and uses, was delivered by E. Weintraub to the former of the two sections.

The chlorination of methane and of natural gas was described by Baskerville and Riederer to a joint session of the sections of photo-, electro- and inorganic chemistry.

The important topic of the utilisation of atmospheric nitrogen was introduced in two addresses before joint sessions of several sections. The first of these discourses, delivered by Dr. S. Eyde, dealt with the oxidation of atmospheric nitrogen and the development of resulting industries in Norway. In the second, Dr. H. A. Bernthsen gave an outline of the process devised by Haber for the synthesis of ammonia from its elements and now being developed by the Badische Anilin und Soda-Fabrik on a manufacturing scale. The purified gaseous mixture is heated to about 600–700° under 200 atmospheres pressure, in contact with a catalyst such as iron, manganese, molybdenum, tungsten, uranium or compounds (nitrides or carbides) of these elements. The ammonia is removed by liquefaction or preferably by solution in water.

In the explosives section, B. Flurscheim described the preparation and properties of 2 : 3 : 4 : 6 tetranitro-aniline, a stable crystallisable compound which, when suitably detonated, explodes with extreme violence. Two crystalline forms of nitro-glycerin were indicated by H. Hibbert.

The section on organic chemistry received the largest number of papers, and the interesting and animated discussions which ensued ranged over a wide field. In the section of indiarubber and other plastics, L. H. Baekeland described the condensation products of phenol and its homologues with formaldehyde, these products being the essential constituents of the plastic material "baekelite."

G. Bertrand and his collaborators contributed to the section of agricultural chemistry a series of suggestive papers on the influence of manganese, boron, zinc and aluminium in catalytic fertilisers. In the section of biochemistry F. Ehrlich described the chemical reactions of certain micro-organisms, and papers bearing on the relationship between chemical constitution and physiological or germicidal action were contributed by C. R. Marshall, by H. G. D. Jowett, F. L Pyman and F. G. P. Remfoy and by G. T. Morgan and E. A. Cooper. To the section of electro-chemistry were contributed a series of papers on the electric furnace and on the electrolytic manufacture of alkali, chlorine and hypochlorite. The estimation of oxygen in iron and steel by carbon reduction in a vacuum electric furnace was described by W. H. Walker and W. A. Patrick. The conservation of forests and water supplies, the utilisation of peat and the problem of waste in coal production were discussed in the section of political economy and conservation of natural resources.

GENERAL LECTURES.

In the first general lecture, Prof. G. Bertrand, of the Pasteur Institute, discussed the part played in the growth of plant life by elements present only in minute quantities. Certain of these elements appear to be essential to the healthy growth of vegetation, and the relationship has been worked out most completely in the case of manganese, which is an essential constituent of the enzyme laccase first isolated from the lacquer tree and found to be effective in the assimilation of atmospheric nitrogen. The addition of manganese compounds to the soil has, in certain instances, resulted in an increase of the crops, and similar results have been obtained with other elements, for example, boron, zinc and aluminium. Artificial manures containing these elements, which are termed catalytic fertilisers, are capable of modifying to advantage the fertility of soils.

The second lecture was delivered by Dr. C. Duisberg, of Elberfeld, who reviewed the latest achievements and problems of the chemical industry, dealing more particularly with improvements in refrigerating plant and with Frank and Caro's process for the utilisation of peat in the production of gaseous fuel, peat gas, and the recovery of ammonia as a by-product. The refined steels recently produced have many remarkable properties. Iron alloys containing chromium, tungsten, molybdenum and aluminium withstand to a remarkable extent, after thermal treatment, the action of mineral acids. A steel containing 60 and 3 % of chromium and molybdenum respectively is not attacked by boiling *aqua regia*. Electrolytic iron, now prepared free from hydrogen, is the ideal metal for electro-magnets, owing to the ease with which it is magnetised and de-magnetised. The lecturer referred to the triumphal progress of the contact process for sulphuric acid in the United States and the increased output for a given weight of platinum. The non-inflammable cinematograph films ("cellite") and non-inflammable celluloid ("cellon") produced from acetyl-cellulose are very promising substitutes for the inflammable materials at present in vogue.

The chemical synthesis of rubber has recently been solved; the lecturer claimed that F. Hoffmann, of Elberfeld works, should be regarded as the true discoverer of synthetic rubber, having in 1909 polymerised isoprine into rubber by the action of heat.

This view of the matter was controverted by Prof. W. H. Perkin in a lecture on the polymerisation of butadiene and isoprene when he referred to Tilden's experiments made nearly thirty years ago on the production of rubber by polymerisation of isoprene by acids. Tilden's actual preparations were exhibited, and the lecturer referred to the successful experiments in rubber formation from amyl-alcohol carried out by an English group of chemists in conjunction with Fernbach, who has obtained this alcohol by a new fermentation process.

In the third general lecture, Prof. Perkin described the permanent fireproofing of flannelette by hydrated stannic oxide, a cheap process which has the advantage of increasing the strength of the material. The last lecture of the series was given by Prof. G. Ciamician, of Bologna, who advocated the utilisation of radiant solar energy, either directly, in promoting photo-chemical change, or indirectly, in intensive cultivation of plants furnishing industrially valuable compounds.

LABORATORY AND WORKS INSPECTIONS.

During the stay in New York a party of the members of Congress visited the works of the Nichols Copper Co. in Brooklyn, and were shown the electrolytic refining of copper and also the purification of the molten metal by the long-established process of "poleing," which is still used to remove last traces of oxide from the metal.

At the close of the Congress two parties set out in special trains on a tour of factory inspection under the personal supervision of Drs. Day and Rosengarten. At Philadelphia, where the visitors were welcomed by the Mayor in the Hall of Independence, an automobile excursion was made to the Atlantic Oil Refinery, where an inspection was made of plants used in the fractionation of mineral oil and the purification of paraffin wax. Pittsburg was the next halt, and the party inspected the Clairton Works of the Carnegie Steel Corporation with its three 400-ton blast furnaces equipped with seven blowing engines for the hot air blast. In the open hearth department are twelve 60-ton basic furnaces in which natural gas is utilised as fuel. This plant has achieved a world's record in the monthly output of steel. A visit was paid to the laboratories and testing station of the U.S. Bureau of Mines and Bureau of Standards. The factories of the Allegheny Plate Glass Co.

were also visited. The furnaces, each containing twenty-four pots, are fired with either natural or producer gas, each pot furnishing sufficient soda-lime glass for one plate, which is annealed, ground with sand and emery, polished with felt and rouge and finally trimmed into shape. The annual output is four millions of square feet of polished glass. At Niagara Falls the party inspected the plant of the Acheson Graphite Co., where they saw in operation electric furnaces producing pure graphite with crystallised carborundum as a by-product. The electric baking of Triscuit was shown at the Shredded Wheat Co's. factory, and the "harnessing" of Niagara was witnessed on both sides of the falls at the power stations of the Niagara Falls Co. and the Ontario Power Co.

At Detroit facilities were given for visiting the Hudson Automobile Works and the factories of Messrs. Parke, Davis & Co. An expedition was arranged to Michigan University at Ann Arbor, where the visitors were entertained by the President, Honorary President and other members of the staff, Professor Gomberg giving a demonstration on the production and properties of triphenylmethyl and its homologues. Three strenuous days were spent in Chicago, the party first visiting the Illinois Steel Co., Indiana, these works having in operation 560 by-products coke ovens, producing 200,000 tons of coke per month, eight blast furnaces with plant for utilising waste gases and forty-two open hearth furnaces. The Heath and Milligan Manufacturing Co. exhibited a modern and highly efficient plant for the production of paints, the machinery throughout being actuated by electricity. The boilers are fitted with automatic stokers, the water is measured in and the ash removed by a vacuum system. A visit to the Union Stock Yards included the inspection of Messrs. Swift's plant for the manufacture of oleomargarin from milk and edible beef fat. A party of visitors was entertained at the laboratories of Chicago University by the professors of chemistry and other members of the teaching staff. Cleveland was the next halt, and here the party visited the Pennsylvania ore dock, with its mammoth travelling cranes, the Cleveland Salt Works and the National Electric Lamp Co. In the last of these establishments was seen a very noteworthy exhibition of the expert glass-blowing required in the manufacture of incandescent lamps containing carbon, tantalum and tungsten filaments.

Boston, the last city on the short trip, was reached on September 24th. An automobile excursion was made to Harvard University, when the chemical laboratories and the Agassiz Museum were visited. The laboratories of the Massachusetts Institute of Technology were also visited. The equipment of the laboratory of industrial chemistry includes various types of furnaces, including an electric vacuum furnace, filter presses, vacuum pumps and special rooms for electrolytic and bacteriological work. Inspection was invited of the experimental paper mill of Mr. A. D. Little, in which paper of good quality is being prepared from the wood of crushed sugar-cane. An excursion to the neighbouring towns of Beverly and Lynn included visits to the United Shoe Machinery Co. and the Sorosis Boot Factory. The party were entertained at luncheon by the General Electric Co., employing 12,000 persons engaged in the construction of alternating and direct-current motors, transformers, arc lamps, and other electric appliances, steam turbines and centrifugal air compressors. One interesting feature is the department devoted to the training of apprentices in mathematics, physics, workshop and foundry practice.

This tour of inspection, in which, unfortunately, only few British chemists participated, was the most instructive feature of the Congress. At every stage of the trip the visitors were met on the train by members of the local committees; full programmes of social entertainments and factory visits were organised; personally conducted excursions contributed to an economy of the visitors' limited time, and the most generous hospitality was extended at each stopping place to every member of the party.

G. T. MORGAN.

PERSONAL AND OTHER NOTES.

MR. E. GRANT HOOPER, Superintending Chemist, Government Laboratory, Vice-President of the Society of Chemical Industry, has been appointed Deputy Government Chemist in succession to Mr. H. W. Davis, who has retired.

Nature reports that Mr. William H. Hogg having been appointed an Inspector under the Board of Agriculture for Scotland, the post of Resident Manager of the Royal Agricultural Society's Experimental Farm at Woburn has become vacant. Applications for the appointment are to be made to the Secretary of the Society, at 16, Bedford Square, London, W.C., not later than Saturday, November 2nd.

Sir Edward Thorpe, on October 12th, unveiled a bronze statue to the memory of Joseph Priestley, the discoverer of oxygen, in Birstall, the town of his birth. The statue was erected by public subscription at a cost of £700.

Sir William Crookes, O.M., F.R.S., was presented with the Society of Chemical Industry's medal in London, by the retiring President, Dr. Rudolph Messel, on October 23rd, in the presence of the President of the Royal Society, Professor Sir James Dewar, and many other distinguished chemists.

A memorial service for the late Mr. H. O. Jones, F.R.S., and Muriel Gwendolen Jones, his wife, who were killed in the Alps in August, was held at the University Church of St. Mary the Great, Cambridge, on October 12th.

The 1912-1913 Calendar of the Bradford Technical College, indicates that this Institution is a centre of increasing activity. The chemistry and dyeing courses include lectures on recent chemical research, chemical engineering, glass working and technical German.

The possession of a University Degree, or its equivalent, seems to be of increasing importance to young men who are seeking the more important and responsible positions connected with the chemical industries. The number of students seeking admission to the University Degree Course in the Manchester Municipal School of Technology has never been so great as in the case of the Session which opened on September 30th. The supply of students entering the Chemical Department of the school, although it has been steadily increasing for some years, has not kept pace with the demand for students who have completed the Degree Course.

CHEMICAL ENGINEERING.

GAS PRODUCERS AND GAS-FIRED FURNACES.

By F. G. Fogg.

At no time has more attention been given to the economical firing of all kinds of furnaces than during the past decade, and it is now established beyond all question that, with very few exceptions, the most efficient method of utilising to the fullest extent the heat units in coal is to transform it into gas and apply it in the gaseous state.

The slow but steady rise in the price of coal has riveted attention upon the most economical method of obtaining the fullest commercial effect of this heating value, and as the tendency is for coal to attain still higher prices the question of its most efficient utilisation is one of the greatest importance.

On all hands direct coal firing is giving place to gas firing, and it is found in general practice that the saving effected is anything from 25 to 50% in the weight of coal consumed.

This striking economy in fuel alone, apart from other incidental advantages, is achieved only when the closest attention is given to the design of both producers and furnaces, and, speaking broadly, it is this aspect of the matter rather than the introduction of any essentially novel feature that has mostly engaged the scientific study of chemists and engineers, and refinements in this direction have within recent years brought the manufacture and application of producer gas to a point of high efficiency.

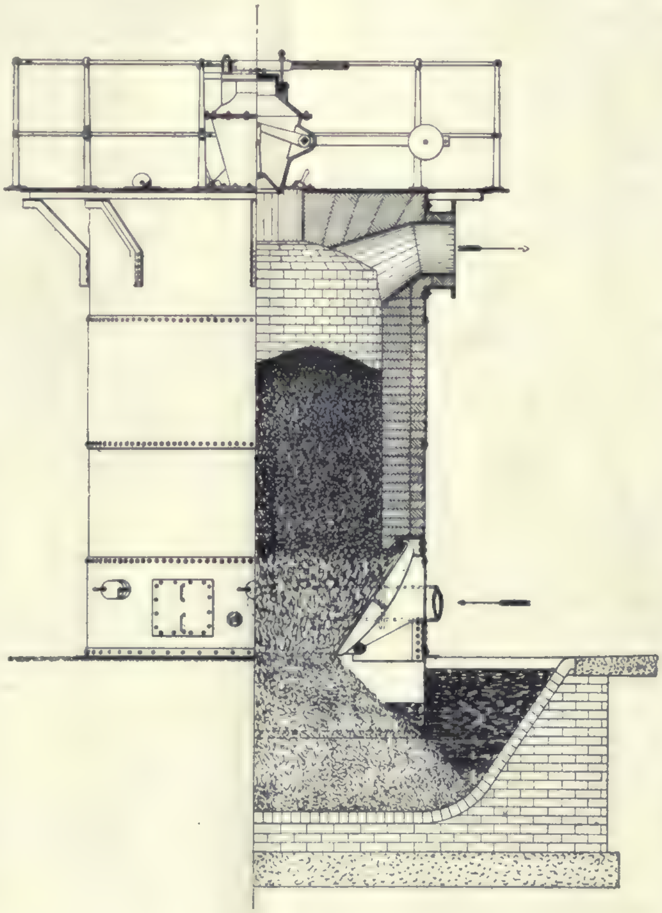


Fig. 1.—Mond Producer.

It is now recognised that old-fashioned gas plants, casually designed and operated by unintelligent labour, are sources of much waste, and modern gas plant is rapidly replacing obsolete types.

In modern gas plant it is not uncommon to obtain a thermal efficiency of 85 % (*i.e.*, 85 % of the heat energy in the fuel is contained as potential and sensible heat in the gas) when the raw gas with its sensible heat is led hot to the furnace, and about 75 to 80 % when the gas is used cleaned and cooled, as is advisable in some operations, but in both cases this high efficiency is obtained only with effective and well-proportioned furnace regeneration.

Producer gas is a mixture of gases, combustible and incombustible, resulting from the complete burning of coal or other carbonaceous matter in a closed vessel supplied with a blast of air, or air and steam. It is the cheapest gas made per unit of heat, as it contains more of the original energy in the fuel than any other artifical gas, and the first object of scientific design and operation should be to make the highest possible proportion of combustible gas along with the complete ultimate destruction of the fuel, so that the residual ash contains practically no carbon.

Leaving out of account what is called "half gas firing," which is really only a modified form of direct coal firing, producers may be divided into three classes according to the design and disposition of the grate, viz., circumferential, central and diagonal. Fig. 1 illustrates the first type (Mond) with the well-known circumferential grate bars so disposed as to give the most effective grate area for a given diameter of producer, which results in the attainment of the maximum speed of gasification, while at the same time producing a uniformly high quality of gas by reason of the deep fuel bed, in passing through which the reactions between the carbon, oxygen, and hydrogen are completed.

The central blast producer (Fig. 2) has no bars, the air and steam being admitted to the fuel through a louvred cone centrally disposed, while in the third class (Duff) the grate bars run diagonally across the producer, forming in section an inverted V (Fig. 3). For producers of large capacity it is found advisable to instal both circumferential and central grates, particularly for the gasification of fuels of fine grading, and in a well-designed producer a gasification rate of 25 lbs. of fuel per hour per square foot of area should with ordinary slack coal be maintained.

The quality and composition of producer gas depend primarily upon the relative proportion of air and steam in the blast, and the depth of the fuel bed, though at the same time refinements in design and a nice adjustment of conditions are important items in obtaining the best results. In this connection the use of a positive blower (Root's type) has obvious advantages over the ordinary steam jet blower, as it allows of the greatest nicety in governing the relative quantities of air and steam to suit the load and varying qualities of coal. A certain amount of steam is always necessary for mechanical purposes in preventing the formation of clinker and ensuring free and continuous working of the producer, and it is at the same time of great advantage in increasing the percentage of combustibles, and therefore the calorific value of the gas.

The first reaction taking place in a gas producer is the combustion of the carbon in the fuel to carbonic acid by an excess of air. This reaction is exothermic and maintains a state of high incandescence in the lower portion of the fuel bed, in passing through which the carbonic acid is reduced to carbonic oxide, while the steam is decomposed into its elements, hydrogen and oxygen, as shown in the following equations :—

(1) $C + O_2 = CO_2$ + 97 kilo calories.
(2) $CO_2 + C = 2CO$ − 39 ,, ,,
(3) $C + H_2O = CO + H_2$ − 29 ,, ,,
(4) $C + 2H_2O = CO_2 + 2H_2$ − 19 ,, ,,

The reactions (3) and (4) are endothermic, and illustrate the effect of, respectively, a smaller and larger proportion of steam in the blast, though since hydrogen and carbon monoxide are almost equal in calorific value the total heating value of the ultimate gas is not greatly effected. The reaction (2) is reversible, but by adjusting the proportion of air and steam in the blast the temperatures of the incandescent zone of the producer can be maintained to establish the reaction in the direction of preserving the carbon monoxide. The presence of CH_4, a very valuable heating agent in producer gas, is due to distillation, and a typical average analysis of ordinary industrial producer gas is as follows:—

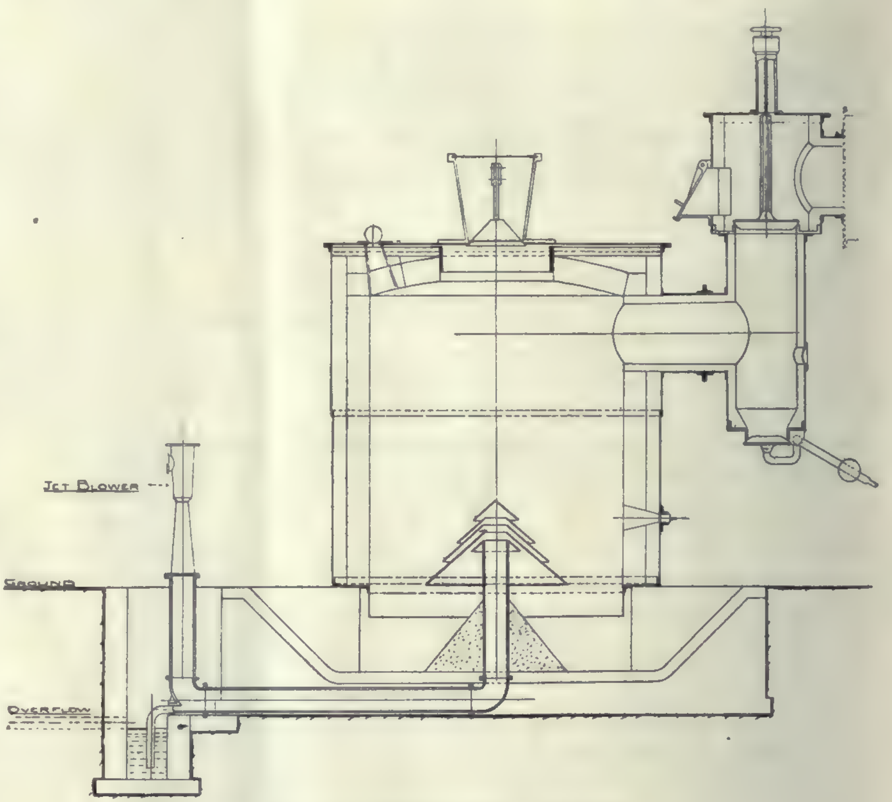


Fig. 2.—Central Blast Producer.

CO	21·0 %
H	15·0
CH_4	3·0
CO_2	5·0
N × H_2O	56·0
Total volume ..	100·0

Total combustible gases 39·0 %
Calorific value (gas dry @ 0°C.).
B.T.U. per cub. ft. .. .. gross 165·5
,, ,, ,, ,, ... nett 144·8

The flame temperature of gas of this composition when burnt in free air would be about 950° C., but the temperatures obtainable by its combustion in furnaces suitably designed with regenerating or recuperating flues are approximately shown in the following table :—

Continuous air recuperation ..	1,050—1,200° C.
Reversing air regeneration ..	1,200—1,450 ,,
Reversing air and gas regeneration	1,450—1,700 ,,

It is here that the great economy of gas firing becomes apparent. Without regeneration or recuperation, gas firing has no great commercial advantage, but with these attributes enormous economies are possible over direct coal firing.

The thermal and commercial advantages of recuperation (or regeneration) of the waste heat in gas fired furnaces was first demonstrated and proved by Siemens in what is known as the Siemens' Reversing Furnace, and the system he evolved was so perfect, that no essential change has been made in the methods he devised some forty years ago. By an arrangement of mushroom and butterfly valves the hot waste gases (products of combustion) are made to pass on their way to the chimney through chambers containing checkered brickwork.

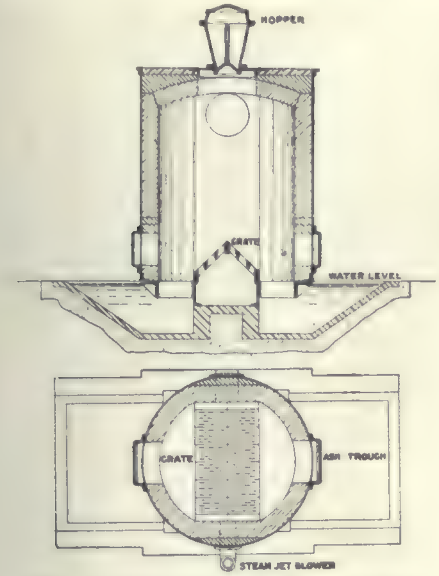


FIG. 3.—DUFF PRODUCER (TWO VIEWS).

The direction of the flow of the gas through the furnace is periodically reversed and the heat imparted to the checkers by the hot waste gases is picked up by incoming air and gas and is thus continuously conserved in the furnace hearth. The general arrangement of such a furnace is seen in Fig. 4.

In operations requiring very high temperatures, such as steel melting, etc., it is usual to employ both air and gas regenerators, by which means temperatures approaching 1,800° C. can be maintained uniformly, while air regeneration alone suffices in many cases for the lower temperatures required in reheating work, etc.

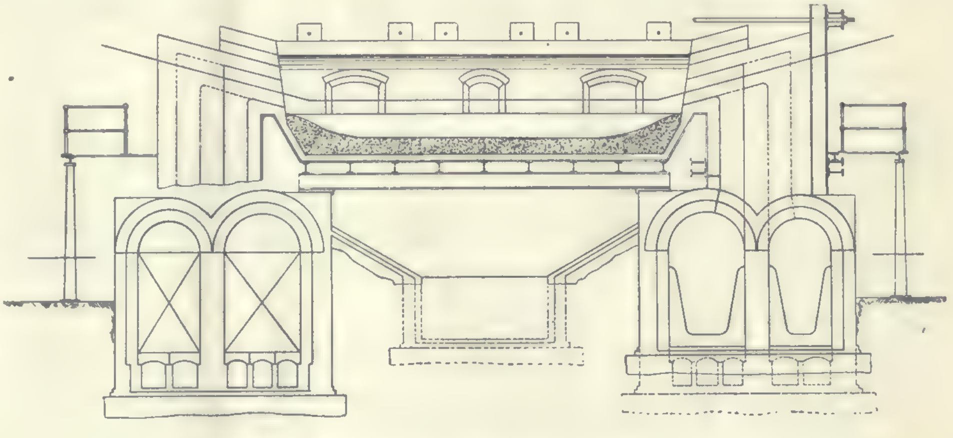


FIG. 4.—STEEL MELTING FURNACE.

The checker brickwork chambers should be built of the highest grade of refractory material with a large capacity for absorbing and emitting heat.

Though the beneficial effect of regenerating hot raw producer gas is very considerable, it is not so marked as when cool and partially cleaned gas is used, and though the ideas of furnace designers vary very considerably as to the relative capacities of air and gas regenerators, the tendency is to build large and very effective air regenerators and to reduce the capacity of the gas regenerators.

In a large steel melting furnace with gas and air recuperation using cool and partially cleaned gas from which ammonia had been recovered, it was found that after passing through the gas regenerating chambers the total combustibles in the gas were increased by over 50%, and its calorific value by 47%. The gas entered the regenerators saturated at 65° C., carrying 25% of water vapour by volume, which, in the presence of unsaturated hydrocarbons (tarry vapour), was decomposed, hydrogen and carbon monoxide being produced.

The recuperation of the air can be effected either by checkered brickwork chambers, as described above, or by continuous parallel counter-current flues through which the hot waste gases are conducted from the furnace hearth on their way to the chimney, the air flues alternating with waste gas flues, the direction of the flow of the hot waste gases being opposite to that of the incoming air. In this system there is no need for reversing valves and the passage of the gas over the furnace hearth is always in the same direction (Fig. 5).

As a highly efficient instance of this type, the "Weardale" calls for special notice, and its construction and operation will be at once understood by reference to Fig. 6.

Temperatures of from 1,000 to 1,250° C. can be uniformly maintained in the Weardale type of furnace, and the degree of heat can be easily and most effectively controlled. Radiation losses are reduced to a minimum as the furnace is almost entirely jacketed with air channels, while the gas is applied to the hearth in such a manner as to give perfectly even heating over the whole area, thus avoiding the uneven heating and local burning so mischievous in direct coal firing.

It is quite ordinary practice to work this type of furnace with a consumption of $1\frac{1}{2}$ to 2 lbs. of common slack coal per square foot of hearth per hour, while in a steel melting furnace with air and gas regeneration the fuel consumption should not exceed at the outside, 6 cwts. per ton of steel made, the material being charged cold.

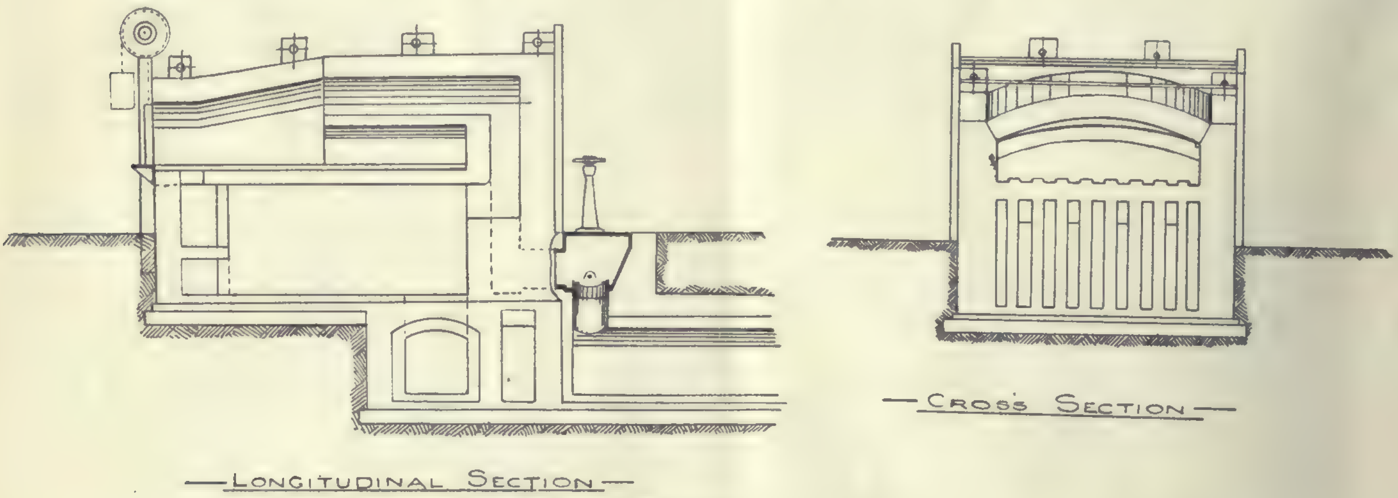


Fig. 5.—Re-Heating Furnace (two views).

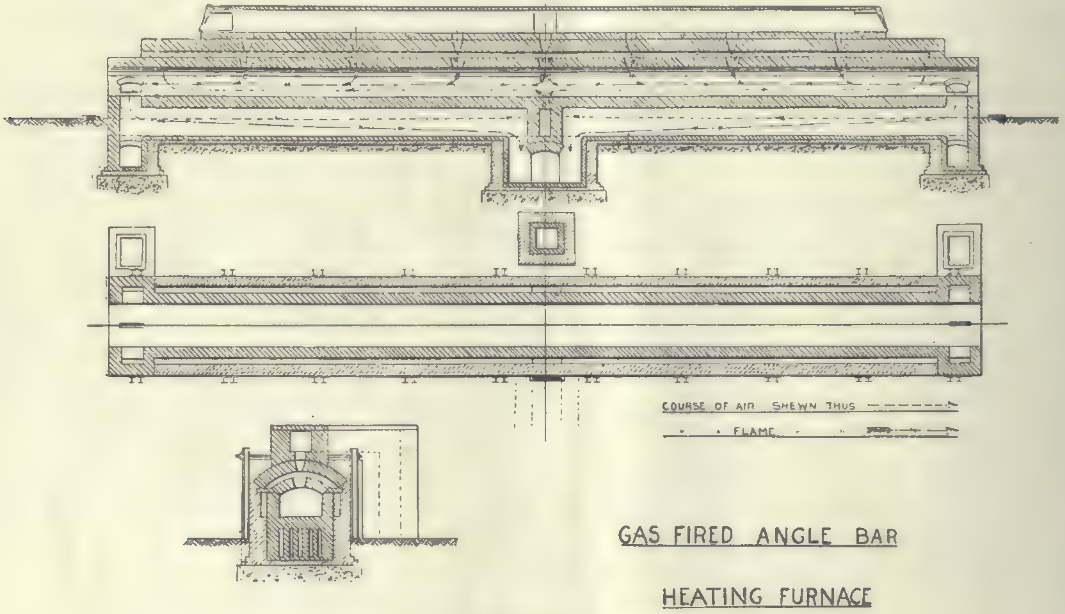


Fig. 6.—"Weardale" Furnace.

There are several refinements in the parallel counter-current design of air recuperation, amongst which the Klonne system may be mentioned favourably, but the regenerator setting involves costly special fire-clay material, and though possibly advantageous in certain special requirements it is doubtful whether the extra outlay required is justified in ordinary applications by the slightly increased efficiency over the simpler settings shown in the illustrations.

For special purposes, such as billet heating, gas fired furnaces are built with an inclined hearth by means of which the billets are discharged automatically by gravity (as the Morgan type), while in other cases the billets are pushed forward to the discharging end mechanically, but in both these types the heating of the furnace by air regeneration is substantially as described above, and though remarkably low fuel consumption is obtained, the initial cost of such special furnaces is heavy and repairs and running costs are apt to discount their overall economy.

(*To be concluded.*)

REVIEWS OF BOOKS.

"LECONS DE CRISTALLOGRAPHIE." By G. Friedel. Pages 310 + iv. with Index and Appendix. Chapters VI., with 383 figures. A. HERMANN ET FILS. Paris, 1911. Price 10 francs.

This work does not claim to be a complete treatise on crystallography, but represents the first lectures of a course on mineralogy, given by the author during several years past to the students of the Ecole Nationale des Mines de Saint Etienne. Accordingly, crystallography is considered primarily in its relationship with mineralogy, and the treatise is limited to a consideration of those properties which serve to distinguish mineral species. From such an introductory point of view, it should prove distinctly useful to the mining student, as well as to the student of chemistry. The earlier portion of the work deals with geometrical crystallography (126 pages), whilst the latter portion treats of the physical characters, especially the optical properties, of crystals (98 pages), as well as general considerations of twinning, deformations, isomorphism and polymorphism. The last two subjects are, however, dealt with so briefly as hardly to be satisfactory to the chemist. The practical methods of crystal measurement and calculation are not touched upon, which perhaps is inevitable in a short treatise written for the special object indicated above. W.A.D.

"THE SIMPLE CARBOHYDRATES AND THE GLUCOSIDES." By E. Frankland Armstrong. LONGMANS, GREEN & Co., London, 1912. Monographs on Bio-chemistry. Second edition. Pages 171 + viii, including Bibliography and Index. Chapters VIII. Price 5/- net.

The success of the first edition of this useful monograph has called for a second edition, which has been brought up to date by the inclusion of recent work, especially that dealing with the glucosides. As pointed out, this new edition will have an additional interest from the botanical and agricultural standpoint. The consideration of the functions of carbohydrates and glucosides in plants is of the greatest interest, and recent developments have been of an important nature. It is hardly necessary to add that this monograph is of distinct value to those interested in bio-chemistry.

"EINFÜHRUNG IN DIE QUALITATIVE CHEMISCHE ANALYSE. ZUM GEBRAUCHE BEI DEN PRAKTISCHEN ÜBUNGEN IM LABORATORIUM." By S. Wiechowski. VERLAG VON JOSEF ŠAFÁR, Leipzig. 1910. Pages 75 + iv, Chapters VII., including 20 Illustrations and 1 Plate. Price M. 2.

This book by Professor Wiechowski, of Vienna, on qualitative analysis is interesting, in the fact that it opens with a theoretical *résumé* of Guldburg and Waage's law; St. Claire Deville's work on dissociation, and Arrhenius's investigations in connection with electrical dissociation.

The tabular form of analysis follows on accepted lines, and deals with the metals and acids generally. At the end of the volume certain useful hints in manipulation and manufacture of the simple glass apparatus required are given.

This work bears the stamp of careful thought in its compilation, and presents its subject in a particularly useful way. It should prove of value, both to the student and analyst, and is a very handy work for the college laboratory, for which it is evidently intended.

"PUBLIC HEALTH CHEMISTRY AND BACTERIOLOGY." By David McKail. SIMPKIN, MARSHALL, HAMILTON, KENT & Co., LTD., London, 1912. Pages 409 + iv, including Index and Appendix. Chapters XVIII. Price 6/6 net.

This small text-book is written for class work, in connection with public health chemistry and bacteriology. It deals in a general way with water analysis, examination of air, soils, foods, and beverages. A chapter is devoted to the more common antiseptics and disinfectants.

The second part is devoted entirely to bacteriology; the chapter on special examination being decidedly good. The book is certainly a useful one, and has evidently been compiled with great care. The general chemist may find in the second part information which may be of distinct value.

"ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA, CHEMICAL, PHYSICAL, AND TECHNOLOGICAL." Vol. I., 1910. Pages 727 + xxxix. J. & A. CHURCHILL, London. Price 21/6 net (paper); 24/- net (cloth).

This work consists of a series of tables expressing the values of constants and is written from the chemist's point of view. It is published as a result of the deliberations of an International Committee, by the Association Internationale des Académies.

Although there is no index, the table of contents is a very satisfactory one, and the information given is accurate. The work is well printed and will undoubtedly be of value to those who desire information in the direction indicated.

"LUBRICATION AND LUBRICANTS." By Leonard Archbutt and R. Mountford Deeley. CHARLES GRIFFIN & Co., LTD., London, 1912. Third Edition. Pages 599 + xiv, including Index. Chapters XI., with 157 Illustrations and Numerous Tables. Price 25/- net.

The last edition of this extremely useful work exhibits generally signs of the care which has been taken over the natural process of revision and extension of subject-matter. As the last edition was dated 1907, the additional matter is naturally of importance.

The lubrication of machinery is an increasingly important factor in the economy of power, and it is satisfactory that there is such a comprehensive and accurate text-book dealing with lubricants and their action, as the one before us.

This edition contains an additional seventy pages of subject-matter, including an account of Acheson's deflocculated graphite, and its possible influence on theory and practice is discussed in some detail.

We cannot do less than congratulate those interested in this subject, on having such a complete and satisfactory work at their disposal. It is in every way what a text-book should be.

Books Received.

"A SECOND YEAR COURSE OF ORGANIC CHEMISTRY FOR TECHNICAL INSTITUTES," by F. B. Thole. Methuen & Co., Ltd., London, 1912. Pages 186 + vii, including Index and Appendices. Chapters XX. Price 2/6.

"MODERN RESEARCH IN ORGANIC CHEMISTRY," by F. G. Pope. Methuen & Co., Ltd., London, 1912. Pages 324 + xi, including 2 Indexes. Chapters IX., with 261 Diagrams. Price 7/6.

"THEORIES OF SOLUTIONS," by Svante Arrhenius. Henry Frowde, London, 1912. Pages 247 + xi, including Bibliographical References and 2 Indexes. Lectures XI., with Diagrams. Price 12/6 net.

"OXIDATIONS AND REDUCTIONS IN THE ANIMAL BODY," by H. D. Dakin. Longmans, Green & Co., London, 1912. Monographs on Bio-chemistry. Pages 135 + vi, including Bibliography and Index. Chapters VI. Price 4/- net.

"THE SIMPLE CARBOHYDRATES AND THE GLUCOSIDES," by E. Frankland Armstrong. Longmans, Green & Co., London, 1912. Monographs on Bio-chemistry. Second Edition. Pages 171 + viii, including Bibliography and Index. Chapters VIII. Price 5/- net.

"CELLULOID; ITS MANUFACTURE, APPLICATIONS, AND SUBSTITUTES," by Masselon, Roberts and Cillard. Translated from French by Herbert H. Hodgson. Charles Griffin & Co., Ltd., London, 1912. Pages 353 + vii, including Index. Divided into 3 Parts and 32 Chapters, with 7 Plates and other Illustrations. Price 25/- net.

"TREATISE ON GENERAL AND INDUSTRIAL INORGANIC CHEMISTRY," by Ettore Molinari. Translated by Ernest Feilmann. J. & A. Churchill, London, 1912. Pages 704 + x, including Index, with 280 Illustrations. Price 21/- net.

"CHEMICAL RESEARCH IN ITS BEARINGS ON NATIONAL WELFARE." Incorporating a Lecture delivered by Professor Emil Fischer. Society for Promoting Christian Knowledge. London, 1912. Pages 80. Price 1/6.

"ELEMENTARY CHEMICAL THEORY AND CALCULATIONS," by Joseph Knox. Gurney and Jackson, London, 1912. Pages 100 + iv, including Index and List of International Atomic Weights. Chapters XII. Price 2/- net.

"THE ELEMENTS OF QUALITATIVE CHEMICAL ANALYSIS," by Julius Stieglitz. Vol. I., Parts I. and II. Theory. The Century Co., New York, 1912. Pages 312 + viii, including Index. Chapters XVI. Price $1.40. Vol. II., Parts III. and IV. Laboratory Manual. The Century Co., New York, 1911. Pages 151 + iv, including Appendix and Index. Sections VIII. Price $1.20.

ANNUAL MEETING OF THE SOCIETY OF CHEMICAL INDUSTRY.

THE Annual Meeting of the Society of Chemical Industry was held this year in New York, beginning on August 31st, when the visiting members of the Society were welcomed at an informal reception at the Chemists' Club, which was made the headquarters of this gathering. The members were also invited by the Verein Deutcher Chemiker to their anniversary meeting on September 2nd, when Dr. F. Raschig lectured on the scientific and technical importance of tar-phenols, in which he referred to the employment of these substances as disinfectants and as shellac-like and plastic materials in the form of their condensation products ("Baekelite") with formaldehyde. The phenols have also played an important part in the manufacture of such explosives as picric acid and the white powder prepared by the lecturer from saltpetre and sodium creosolsulphonate. After a second lecture by Dr. F. W. Frerichs on "Thirty-two Years in the United States as Chemist and Manufacturer," the visitors were entertained at luncheon and in the evening at a kommers by the Verein Deutscher Chemiker. At the Annual General Meeting of the Society, held in the Rumford Hall of the Chemists' Club on September 3rd, the President, Dr. Messel, F.R.S., being in the chair, an address of welcome was pronounced by the Hon. J. P. Mitchell, Acting Mayor of New York. The President welcomed the new President elect, Professor Marston T. Bogert, and then delivered the Annual Address, in which he reviewed briefly the progress of industrial chemistry, mainly in regard to inorganic products. Special reference was made to the fixation of atmospheric nitrogen, the manufacture in the electric furnace of aluminium, graphite and carborundum, and the thermit process and its applications. The coal tar industry is the largest consumer of inorganic products and the cause of the invention of the catalytic process for sulphuric acid. The President then referred to his own early researches, commenced in 1875, on the manufacture of sulphur trioxide with the aid of catalysts, and paid a tribute to work in the same field carried out by Knietsch of the Badische Fabrik.

The address concluded with a reference to the college training of students intending to take up industrial chemistry as a career. The President's views deserve serious thought, both because of his high position among chemical manufacturers and also on account of his recent appointment to the governing body of the Imperial College of Science and Technology. He replies in the negative to the question, "Can such technical knowledge be acquired by the student before entering into practice as well as the scientific knowledge that will be of use to him and to his employers in all or the majority of [chemical] industries?" and he adds, "If it cannot be done is it worth the student's while to sacrifice much time at the most important and critical part of his life, as far as learning is concerned, in acquiring technical knowledge which may be of no assistance to him in after life?"

After the award of the Society's Medal to Sir William Crookes, O.M., F.R.S., who was unfortunately not able to be present, the members were entertained at luncheon by the Chemical Club.

From September 4th till September 13th the members of the Society of Chemical Industry participated in the proceedings of the International Congress of Applied Chemistry. The banquet of the Society was held at the Hotel Waldorf-Astoria on September 13th.

G. T. MORGAN.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By EMIL HATSCHEK.

CHAPTER IX. (*Continued*).

THE different rate of adsorption of substances present in a solution can be strikingly demonstrated, and can be utilised for proving their presence in extremely minute quantities by allowing the solution to rise in long strips of filter paper. While this takes place, the dissolved substances are adsorbed by the fibre, so that beyond a certain height the liquid in the paper consists of pure solvent only. Different substances generally rise to different heights, and can be identified by their colour, or, if colourless, by appropriate reactions. The process can be demonstrated, for instance, with a very dilute solution of turmeric and picric acid, which is allowed to rise in a strip of filter paper about 12 ins. long. The strip is stained yellow, but if it is then exposed to ammonia, only the lower portion turns brown, showing that the turmeric has not risen as far as the picric acid. The method, which deserves to be more widely known than appears to be the case, may be used for showing the presence of colouring matter or preservatives in articles of consumption, and for many similar purposes. It has been developed—under the title of "Capillary analysis"—principally by F. Goppelsroeder, of Basle, who has demonstrated its extreme sensitiveness in favourable cases.

It is obvious that in all instances in which reactions take place in the presence, or lead to the formation, of finely divided solid matter, adsorption is possible, and may account for changes in concentration or losses. It offers thus a somewhat easy explanation of such phenomena, which, however, ought not to be taken as established without investigation, that is, measurements and the plotting of a curve, which must have the character of the adsorption isotherm, to establish this interpretation of what occurs. If the curve obtained is of a different type, it shows that adsorption, if it takes place at all, is accompanied by some other process. In this connection it should also be borne in mind that, even if chemical combination between the adsorbent and the adsorbed substance is possible, the two processes need not occur simultaneously. This point is strikingly illustrated in an experiment by Bayliss, in which the blue Congo red acid—liberated from the dyestuff, which is a sodium salt, by acid—is adsorbed by aluminium hydroxide. The latter is stained *blue*, although all the salts of the acid are *red*, which shows that adsorption has taken place without chemical combination. The latter, however, occurs on warming, when the colour of the hydroxide changes from blue to red.

A process, which in a way may be looked upon as the converse of adsorption, is the extraction of a substance containing an admixture, with a solvent in which the latter only is soluble. It is evident that, if there is simply mechanical mixture, and if a sufficient quantity of solvent is employed, the whole of the soluble matter will be extracted by the first lot of solvent. It is equally obvious that this cannot be the case if the second substance is *adsorbed* by the first: in that event the first lot of solvent will, indeed, remove a large fraction of the soluble matter; but as much of it as establishes equilibrium under the given conditions will be retained. A second lot of solvent will again remove a—much smaller—quantity, and so on. If a curve is plotted with the, preferably equal, volumes of solvent as abscissæ, and the amounts of soluble matter still retained as ordinates, curves of a hyperbolic type are obtained, and it is quite easy from these to construct the adsorption isotherm for the system under examination, as will be clear from an actual example. Rubber, as is well known, contains varying amounts of "resin," *i.e.*, of substances soluble in acetone, and the results of extraction with successive equal portions of that solvent are shown in Fig. 14, taken from an investigation by D. Spence and J. H. Scott, published in the "*Kolloid-Zeitschrift.*" The amounts of resin still retained after each extraction are plotted as ordinates of the curve in full line at equal distances apart. It will be noticed at once that the first lot of solvent extracts a very large portion of the total resin contents, as shown by the length *ab* on the ordinate *ac*. Similarly, the portion extracted by the second lot of acetone is given by the—much smaller—length *a′ b′* on *a′ c′*. The whole curve resembles a hyperbola, and it can easily be shown that the whole process is an inverted

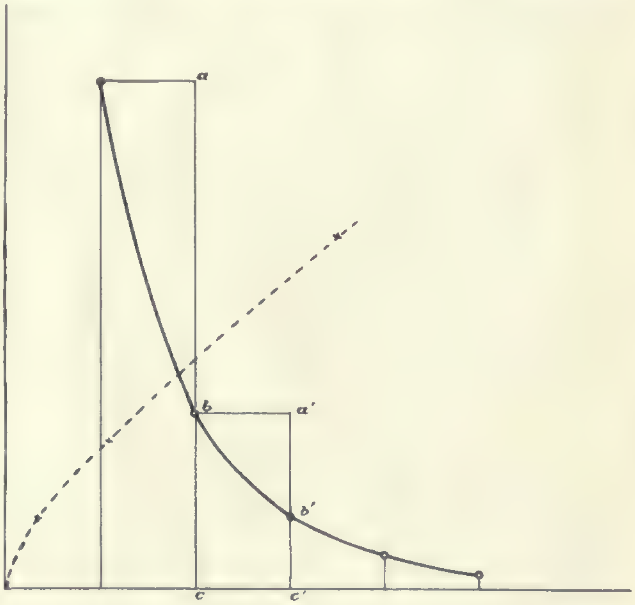


FIG. 14.

adsorption, both by analytical and by graphical methods. To adopt the latter, we consider the two portions of the ordinate *ac;* the part *ab* has gone into solution, while *bc* is retained by the rubber. The latter therefore represents the amount adsorbed which is in equilibrium with the concentration in the solvent produced by dissolving the quantity *ab*. If, accordingly, we plot the lengths *ab*, *a′ b′*, — — as abscissæ, and the lengths *bc*, *b′ c′* — — as ordinates we obtain a curve which must have the character of the adsorption isotherm if the extracted matter is really retained by adsorption on the insoluble portion. This curve is plotted in dotted line, and it is obvious that it is of the familiar parabolic type.

We have so far considered only phenomena in which the change in surface energy has been held to be the determining factor, and have disregarded the fact, with which we are already familiar, that boundary surfaces are generally the seats of electric charges. It is more than probable that these may affect adsorption, and there are some striking phenomena in which the electric factors appear to play the most important or indeed an exclusive part. If, for instance, a ferric hydroxide solution is passed through a column of sand—carefully purified—the hydroxide is completely retained, and only clear water leaves the end of the column for a time. The same thing occurs with a solution of night blue, as has been shown by Dreaper and Davis. In both cases the sand is capable of retaining only a quite definite quantity: when this has been reached, the liquid passes through unaltered. Both ferric hydroxide and night blue belong to the, not very numerous, class of positive colloids, while silica, like most substances, assumes a negative charge in contact with water. It is, therefore, reasonable to assume that the positive colloidal particles are discharged and retained by the negatively charged sand grains. Night blue is retained with such tenacity even by a smooth glass surface that vessels which have contained the solution cannot be washed clean with water alone. The phenomenon does not occur in an alcoholic solution of the dye, and, if the latter has been adsorbed on sand from an aqueous solution it can be removed by subsequent washing with alcohol.

It must be noted that the clear liquid which passes out of the column of sand is no longer, like the dye solution, neutral, but acid, *i.e.*, dissociation has taken place. The adsorption of highly dissociated substances is a subject to which passing reference has already been made, but our knowledge in this respect is still very incomplete. Cases of both positive and negative adsorption are known, and also numerous instances in which the anion and the cation are *not* adsorbed in equivalent quantities, that is, the solutions after adsorption show an excess of either, generally the anion. This, as already mentioned, is the case with potassium sulphate in van Bemmelen's experiments, also with salts of aniline and with many dyestuffs. The whole subject is in urgent need of much further investigation.

(*To be concluded.*)

THE AUTUMN MEETING OF THE IRON AND STEEL INSTITUTE.

THE chief subject of discussion at the Autumn Meeting of the Iron and Steel Institute, held at Leeds from September 30th to October 4th, has been that of "Rail-breakage" due to piping and segregation of the steel ingots used in their manufacture, and several interesting papers have been contributed upon possible remedies for these defects.

Although defective rails are not unknown in this country, it is in America that accidents from this cause are proportionately the more numerous and disastrous. Dr. Puppe, of Breslau, in the course of his paper upon "Rolling Mill Practice in the United States," stated that whereas in 1878 there were eleven rail-rolling mills across the Atlantic, with an output of 34,000 tons, the number is now fourteen, with an annual production of 3,000,000 tons. The size and output of the individual mills has therefore been enormously increased during the past thirty years, and it was questionable whether so much care was bestowed upon the quality of the raw materials and of the finished rails as in the earlier days of the manufacture. Single rail-mills in the United States of America are now producing from 3,500 to 4,000 tons of steel rails per twenty-four hours, and it is an admitted fact that rail-breakages have been much more numerous in that country than in Europe. These accidents are partly due, no doubt, to the greater severity of the condition of railway service in U.S.A., the loads, the speeds and the extremes of temperature between summer and winter all being much greater than in the United Kingdom. This is an argument, however, for giving greater care and attention to the chemical condition and physical characteristics of the steel used for the rail-mills, and to the testing of the rails produced.

The increase in the demand for special steel rails in U.S.A. proved that at last these facts were being recognised by railroad engineers.

Sir Robert Hadfield, F.R.S., contributed two interesting papers to the Congress on the same subject. In the first of these he discussed a new method of preparing steel ingots free from piping blow-holes and segregation, and in the second he described a new method of revealing segregation in the ingot when it has occurred.

The new method of preparing sound ingots is to cast the ingot in the mould with its wide end uppermost, and to keep the top of the cast ingot molten for a considerable time by burning charcoal upon the surface of it. The new test for segregation consists in adding a small quantity of copper to the ingot while still in a partly fluid condition in the mould; the higher specific gravity of this copper as compared with molten iron causing it to sink through the central portion of the ingot and to reveal the extent of the segregation by its distinctive colour.

Dr. Hans Goldschmidt, of Essen, described a second method for improving the soundness of steel ingots, this being by the addition of "thermit" to the ingot *before solidification has begun*. Formerly the "thermit" cartridge was only used for increasing the temperature and fluidity of the upper portion of the ingot—this gave unsatisfactory results. The new method is based upon the use of the thermit cartridge at the *bottom of the ingot*, the cartridge being quickly plunged to the bottom of the molten steel before any solidification has had time to occur.

Dr. J. E. Stead, F.R.S., and Mr. Benjamin Talbot, of Middlesbrough, during the discussion on the above papers, described a third method of obtaining sound steel ingots which had been practised with most successful results at the works of the Cargo Fleet Company at Middlesbrough. This method consists in making the steel ingot absolutely sound by aid of aluminium or silicon, a central pipe being left, as in the ordinary method of manufacture. The ingot is then, however, quickly stripped, placed in a soaking pit for a short time, and then, while its centre is still liquid, is compressed by a few passes through the "cogging-mill," in order to reduce its sectional area. The resulting semi-cogged ingot is found to be free from cavity and absolutely sound; and rails rolled from the upper portion of these ingots have stood the usual physical tests for rail-steel remarkably well.

As regards the practical application of Dr. Hadfield's and Dr. Goldschmidt's methods, the former stated that steel ingots made by his process of manufacture, showed an average waste of only 8 %, 92 % of the fluid steel poured into the mould being fit for use. This would indicate a saving over the present method of manufacture of 8*s*. to 12*s*. per ton, in addition to the great advantage of obtaining a sounder ingot and rail. Dr. Goldschmidt claimed for his improved thermit process, that in a plate-rolling mill the number of plates rejected owing to defective ingots was only 3 %, as compared with 15 % in mills using the ordinary methods of manufacture.

Other papers of interest to chemical engineers, were those upon "The Utilisation of Coke-Oven Gas," by A. Greiner, of Seraing, and upon "Iron and Nitrogen," by J. H. Andrew.

The first-named author gave particulars of the experimental work carried out at the Cockerille Works at Seraing, in Belgium, with coke-oven gas for heating a Martins-Siemens steel furnace. This substitution of coke-oven gas for ordinary producer-gas had led to reduced waste, a higher temperature, a saving in time, and to lower cost of the steel castings produced. The only drawback is increased maintenance charges, due to the greater wear and tear on the crown of the furnaces.

Mr. Andrew summarised the results of his research upon the action of *Nitrogen upon Iron and Iron-carbon alloys* at critical ranges of temperature as follows:—

1. Iron and iron-carbon alloys absorb small amounts of nitrogen when melted under a high pressure of the gas.

2. The absorption of 0·3 % of nitrogen entirely suppresses the critical changes occuring in pure iron, and prolonged heating *in vacuo* is required in order to denitrogenise the metal.

3. The absorption of 0·25 % of nitrogen by a 0·6 % carbon steel, lowers the Ar1 point to a marked degree. Such a nitrogenised steel can only be brought back to the normal state of a pure steel by several weeks' heating *in vacuo*.

4. The critical changes occurring in iron and steel are due to the coalescence of like molecules, and this coalescence is due to the contraction of the metal during the cooling, bringing the molecules sufficiently near together for the force due to the molecular attraction of like molecules to exert itself, and to overcome the influence of the intervening molecules. The absorption of nitrogen, followed by the formation of iron nitride prevents, by keeping them further apart, the iron molecules and the iron carbide molecules from coalescing with molecules of their own kind.

5. The effect of nitrogen upon the mechanical properties is made evident by consideration of its influence upon the critical change.

6. Hydrogen has no influence upon the critical changes when introduced into the liquid metal under pressure.

JOHN B. C. KERSHAW.

THE ALKALINE WATERS OF THE LONDON BASIN.[1]

By JOHN C. THRESH, M.D., D.Sc.

IT is now over twenty years since I first became acquainted with the somewhat curious character of the waters derived from the chalk and Thanet sand in various parts of Essex, and during the last twelve years I have been making a somewhat detailed analysis of all deep well-waters concerning the source of which I could obtain any reliable information. In 1901 I published a report on "The Water Supply of the County of Essex," and included therein a map showing that to the east of a curved line passing from Dedham in the north to Barking in the south the waters derived from the chalk (save at the Purfleet outcrop) were "soft," and contained more or less salt and sodium carbonate, whereas on the west of this line the waters had the ordinary character of chalk waters, that is, they contained very little salt and were free from sodium carbonate, but contained a considerable quantity of chalk in solution and were therefore "hard." I also pointed out that in many localities the beds between the base of the London clay and the top of the chalk yielded waters containing an excessive amount of lime and magnesium salts, chiefly sulphates.

In the map above referred to the dotted line is said to suggest a probable fault in the chalk. In some cases the marked difference in the character of the water derived from wells not more than, perhaps, one mile apart, seems to indicate the presence of a fault, but there is no other evidence in support of this suggestion, and my further investigations lead me to conclude that it is not necessary to assume the presence of a fault to account for the facts observed.

TABLE I.

Source.	1	2	3	4	5	6
					London	
	Chalk. Eton.	Chalk. Datchet.	Chalk. Datchet.	Chalk. Shepherds Bush.	Chalk. Strand.	Chalk. Lambeth.
Calcium Carbonate ...	21·8	16·3	14·7	5·0	3·0	12·75
Calcium Sulphate ...	6·4	—	—	—	—	—
Calcium Chloride ...	—	—	—	—	—	—
Magnesium Carbonate	—	3·6	3·1	3·5	2·1	7·85
Magnesium Sulphate	—	—	—	—	—	—
Magnesium Chloride	2·3	—	—	—	—	—
Sodium Carbonate ...	—	3·4	5·6	21·6	12·8	6·9
Sodium Sulphate ...	—	7·6	7·6	24·1	18·1	11·1
Sodium Chloride ...	1·1	5·8	5·6	22·6	18·2	14·4
Sodium Nitrate ...	3·5	1·3	1·2	—	—	—
Silicia, etc.	1·4	1·4	1·9	·6	1·2	1·0
Total	36·5	39·4	39·7	77·4	55·4	54·0
Hardness	30°	22°	18°	8°	5°	20°

All the observed results admit of another explanation. So long as the water in the chalk contains carbonic acid it continues to dissolve the chalk and open out the fissures. When all the acid has been used up in dissolving the calcium carbonate it no longer possesses the power of opening out the fissures, and as the chalk becomes more compressed by the superincumbent mass of sand and clay it becomes so dense as almost to be impervious. Beyond this point therefore the water cannot travel in the chalk, and it comes up through the fissured chalk into the sands above and then becomes exposed to their softening action. The compact chalk acts very much like a fault would do assuming a solid impervious stratum abutting upon a pervious one.

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[1] Reprint of a paper read before the Essex Field Club, March 30th, 1912.

I do not purpose dwelling so much upon the geological aspect of the question as upon the varying character of the waters derived from the chalk and Thanet sands in different parts of the London basin, but more especially in Essex, and of offering an explanation for the variations in character.

The nature and progress of this change is well exemplified by the following analysis of waters taken from various wells sunk into the chalk at Eton, Datchet, Shepherds Bush, the Strand and Lambeth, London.

Note 1. The decrease in the calcium carbonate up to London and its increase towards Kent.
,, 2. The appearance of sodium carbonate and its increase towards London and decrease towards the southern outcrop.
,, 3. The disappearance of calcium sulphate in the waters under the London clay.
,, 4. The appearance of sodium sulphate in the waters from under the London clay.
,, 5. The increase and decrease in the amount of sodium chloride.
,, 6. The whole series showing a marked change in the character of the chalk water as the distance from the outcrop of the chalk increases.

The next Table (II.) of analyses includes typical samples of water taken in Essex along a line almost north and south from the bare chalk at Foxearth through Halstead, Bocking, Braintree, Witham, Chelmsford and Billericay to Grays,[1] where the chalk again outcrops.

Well (No. 1) is on the outcrop of the chalk. The well (No. 2) at Datchet is nearer the chalk outcrop than well No. 3, and the latter therefore has a greater covering of London tertiaries. Wells Nos. 4 and 5 are bored through a considerable thickness of London clay. At Lambeth we are approaching the chalk outcrop in Kent and Surrey.

TABLE II.

Source.	Foxearth.	Halstead.	Bocking.	Braintree.	Witham.	Billericay.
Calcium Carbonate ...	31·0	25·3	21·9	5·3	2·8	1·8
Calcium Sulphate ...	—	—	—	—	—	—
Calcium Chloride ...	—	—	—	—	—	—
Magnesium Carbonate	—	2·3	4·4	5·5	1·2	2·8
Magnesium Sulphate	6·6	2·9	—	—	—	—
Magnesium Chloride	1·6	·2	—	—	—	—
Sodium Carbonate ...	—	—	3·1	19·8	26·7	26·3
Sodium Sulphate ...	—	—	9·0	11·8	10·8	9·4
Sodium Chloride ...	4·5	14·0	28·0	67·2	78·3	36·5
Sodium Nitrate ...	·2	·4	·2	·2	·2	·2
Silica, etc.	2·0	·9	1·0	·2	·5	1·0
Total	45·9	46·0	67·6	110·0	120·5	78·0
Hardness	40°	32°	26°	11°	5°	5°

(*To be continued.*)

COMMERCIAL AND GENERAL NOTES.

The Syndicate of German Nitrite Producers is Dissolved.

During the last ten years or so the production of nitrite in Germany has been monopolised by a number of important lead works, such as Bergmann Simon, C. Leyendecker & Co., Lintgans, and a few others, which formed a cartel or syndicate. This enabled them to regulate the prices and to maintain them at a level which the consumers considered unreasonably high. The position of monopoly of the nitrite syndicate has now, however, come to an end. In consequence of the growing production of atmospheric nitrates in Norway, Sweden and Switzerland, which enables the producers to manufacture nitrite much cheaper than the product obtained from nitrate of soda, the German producers of the latter article are no longer able to compete, and quite a number of firms have discontinued this branch of their business. The syndicate, unable to resist the growing influence of Norwegian competition, has, therefore, been dissolved.

Soap from Waste Soda Liquors.

Waste lyes which have been used for the purpose of treating vegetable fibres, especially cocoanut fibre, can, according to the "Société Commerciale des Crins," be utilised in the manufacture of hard and soft soaps. The process consists in filtering the waste lyes with a view to eliminating the matter held in suspension; the filtered liquor is then mixed with oils or fats in proportion varying according to requirements, the operation of soap-making being performed in the same manner as with fresh lye. It is claimed for this invention that it presents the two-fold advantage of economically utilising a waste product, which can only be recovered at great expense if it is desired to use it over again, for the treatment of vegetable fibres, and by reason of the heavy cost of recovery, lye is generally run to waste; and a rapid and economical production of soap, on account of the presence in the lye of considerable quantities of dissolved resins, etc., which impart to the soap certain properties not obtained by the use of ordinary lyes.

Artificial Graphite.

Although the process for the manufacture of artificial graphite was patented barely seven years ago, its commercial development has been so rapid that at present the output of artificial graphite in the United States is greater than the whole domestic production of natural crystalline graphite.

The manufacture of the artificial product is conducted by means of electric furnaces, an anthracite coal carrying small amounts of evenly distributed impurities being the material from which the ordinary grades are made. For obtaining the purest grades of graphite, petroleum coke is substituted for anthracite.

Use of Pine Tar to Denature Olive Oil.

The Treasury Department of the United States has issued instructions to the collector of customs to allow the use of pine tar in denaturing olive oil, provided that not less than 2 % of tar is added and that particular care be taken in mixing the tar thoroughly with the oil. This decision is the result of an investigation by the Bureau of Chemistry into the question whether the use of pine tar as a denaturant for olive oil is permissible.

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[1] The analysis of Grays water will be found in Table VII., No. 6.

An Interesting Trade Publication by a French Firm.

The well-known essential oil distillers of Grasse, France, Messrs. Roure-Bertrand Fils, have issued an English edition of their latest Scientific and Industrial Bulletin containing the results of research work in, and analyses of, several essences, as well as a review of the market for the commodities for the year 1911 and up to April of this year. This book includes a treatise on the direct estimation of geraniol in oil of citronella, by Justin Dupont and Louis Labaune, and the result of a botanical study of cypresses by E. A. & A. Camus. A summarised study of certain essential oils, including parsnips, wild cherry of the marshes, and carrot, follows these treaties, while the remainder of the volume is devoted to notes on some essential oils, descriptions of various raw materials, as well as a review of recent publications on perfumes and essences.

Value of Coal-Tar Products in Germany.

Over a million tons of coal-tar was recovered last year in Germany as a by-product of the coke and gas industries. This represented an increase of over 100 % in ten years, and the selling value of the products amounted to some 40,000,000 marks. In Germany about 90 % of industrial works of this kind are made to yield such products, as against less than 20 % in America. In celebration of the centenary of the gas industry the *Berliner Illustrierte Zeitung* recently published an article setting forth the important part played by coal-tar products in modern industry and domestic life.

Foremost among these coal-tar products are benzol, toluol, xylol, solvent naphtha, ammonia, and the cyanides; next come pitch, anthracene, pyridin, naphthalene, the light, medium and heavy oils, and in further development etheric oils, perfumes, drugs and dyes. The work involved gives employment to an army of people of every grade, from the highly trained scientific expert and investigator, through the ranks of merchants, clerks and skilled mechanics, down to day-labourers. The interesting article concludes with a prophecy of further important developments of this industry, as "unknown possibilities yet dwell in the once despised and rejected mass of refuse that has proved so rich a mine."

Oil of Petitgrain from the Philippines.

One of the common and cheap bases of perfumes is oil of petitgrain, made by distilling the leaves of the wild or bitter orange. At present a large part of the world's supply of petitgrain comes from Paraguay, where the wild orange trees are so abundant and vigorous that the leaves can be gathered in vast quantities at all seasons of the year.

Although it requires some 200 or more kilos of the leaves to produce 1 litre of the pure oil, the value of this is so high and the cost of labour so cheap, that a considerable profit is realised.

As the Philippine Archipelago is the home of several, if not actually all species of citrus which could be utilised for the purpose of orange-leaf-oil production, interesting experiments have recently been made with the object of determining the practicability of extracting oil from the peel of Philippine citrus fruits. The results are very satisfactory and there is a great possibility of a vast increase in the production of oil of petitgrain.

A New Artificial Silk Concern.

The formation of a new French company for the manufacture of artificial chappe has created a stir among the German manufacturers of real and artificial silk. The reason for it is the extreme cheapness of this new product, which will enable it to compete not only with the real chappe, but also with mercerised cotton. The materials made of the artificial chappe are said to resemble real silk goods more closely than any others on the market, and velvets of the new chappe can hardly be distinguished from silk velvets. The difference in price is about 8 fr. per kilo. The company is trading under the style of "La Société La Schappe Nouvelle" and the capital is 3,000,000 fr.

The Origin of Holes in Swiss Cheese.

The formation of the so-called "eyes" in Swiss cheese is a subject of some importance to the biological chemist. The holes or eyes are a prominent characteristic of certain makes of cheese, the commercial value of which depends largely on the proper size and spacing of the holes; defects in the formation cause a depreciation of the value of the cheese. With the object of assisting the American cheese-makers to obtain the best possible result from their labour, the Bureau of Animal Industry undertook exhaustive research work with regard to the formation of the holes in cheese. The result of the investigation is embodied in a recently issued Bulletin (No. 151), from which we quote a few interesting facts.

"The gases of normal 'eyes' in Emmenthal cheese are exclusively carbon dioxide and nitrogen, and of these only the former is of significance. The latter accompanying the carbon dioxide in normal eyes is that of air originally included in the curd at the time of making. There sometimes occurs during the initial fermentation an evolution of gas characterised by the presence of hydrogen. This is believed to be due to the gaseous fermentation of sugar. The hydrogen from such an initial fermentation may sometimes linger to contaminate the gas or normal eyes. The two fermentations are distinct, and are characterised by their gaseous products. The one is detrimental, the other being very desirable in a good Swiss cheese.

"High oxygen absorbing power, combined with low permeability of the cheese to air, render the interior thoroughly anaerobic and consequently favourable to the growth of anaerobic bacteria. A comparison between the amount of carbon dioxide involved and the total volatile fatty acids shows that the activity of the bacteria of Von Freudenreich and Jensen is not sufficient to account for all the carbon dioxide found. It was ascertained that cheese was capable of retaining a very large amount of carbon dioxide."

The possibility is suggested that there are two phases in the formation of normal eyes, a saturation of the body with carbon dioxide, and an inflation of eyes; and the bearing of this hypothesis on the production of gas by a specific cause is discussed in the report.

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

14285/11. W. ANDERSON, Helensburgh, J. MEIKLE, Glasgow, and C. W. FULTON, Paisley. **Distilling Process.** 16 June, 1911.

Relates to the concentration and/or evaporation or distillation of liquids which may contain animal, vegetable or mineral matter in solution. In accordance with this invention, the process consists in heating the liquid under vacuum to convert substantially the entire body of liquid into entrainment, transferring the entrainment to a second heating surface and heating under vacuum the entrainment so transferred. (1 claim. 1 Fig.)

14499/11. P. A. NEWTON, London. **Dyes.** 19 June, 1911.

A vat-dye is obtained by heating 2-amino anthraquinone with thiophosgene in presence of an organic solvent of high boiling point, for example, nitrobenzene; the product dyes orange shades. (1 claim.)

14588/11. G. P. GUIGNARD, Melun, and H. L. A. M. WATRIGANT, Lille. **Alkali Cyanides.** Dated, under the International Convention, as 16 January, 1911.

In a process for the recovery of hydrocyanic acid from gases by absorption in alcoholic caustic alkali or alkali-oxide solution, the water resulting from the reaction is removed in proportion to its formation, preferably by the addition of alkali metal, the alkali cyanide being in consequence precipitated as it is formed. (2 claims.)

14628/11. F. L. TEED, H. L. SULMAN and H. F. K. PICARD, London. **Sulphur.** 20 June, 1911.

Sulphur is obtained by mixing gases containing oxides of sulphur with non-sulphurous reducing gases, which may be mixed with inert gases, and bringing them into contact at a suitable temperature, for example, 750° to 1,000° C., with a suitable solid contact agent. Suitable reducing gases are hydrogen, hydrocarbons, carbon monoxide, coal gas, water gas, or producer gas, with or without steam or water vapour. Suitable contact agents are spongy platinum or platinized pumice, magnesia, calcium sulphate, iron oxides, etc. (4 claims.)

18004/11. J. LANDIN, Stockholm. **Dietetical Products.** Dated, under the International Convention, as 8 August, 1910.

Dietetical products or preparations are manufactured, according to this invention, by adding to nitrogenous or fatty substances or carbohydrates, either alone or in mixtures, compounds of radium, polonium, thorium or actinium, either alone or together, or impregnating the said substances with solutions of the said compounds. (2 claims.)

18356/11. J. Y. JOHNSON, London. **Isoprene.** 14 August, 1911.

Isoprene is manufactured from isopentane by treating the isopentane with a halogenating agent so as to introduce one atom of halogen into the isopentane molecule, then treating this product with an agent which will split off halogen hydride, then treating the product (with, or without, first acting on it with alumina, or a compound containing alumina) with a halogenising agent, so as to produce a dihalogen isopentane, and then treating this product with a body capable of splitting off halogen hydride (afterwards, if necessary, acting on the product with alumina, or a compound containing alumina). (4 claims.)

19535/11. A. R. WILSON, Hornchurch. **Margarine.** 1 September, 1911.

Milk used in the manufacture of margarine is treated in such a way that the curd does not enter into the composition of the margarine, but is obtained as a by-product. The milk is treated in accordance with this invention as follows:—The cream is abstracted and the separated milk is pasteurised and soured preferably with addition of a suitable culture. The culture brings about certain changes in the character of the milk, one of the results of which is that the curd is precipitated. (2 claims.)

19838/11. E. C. R. MARKS, London. **Sterilising Water.** 6 September, 1911.

The invention relates to the process of ozonising water by means of pumps by which a mixture of ozone and air is supplied to a sterilising apparatus. According to this invention, small quantities of water are supplied with the mixture of ozone and air to the pump whilst it is sucking in the mixture. The quantities of water are not only sufficient to prevent the inner metal parts of the pumps from oxidation, but to render unnecessary the employment of oil as a lubricant. (2 claims. 1 Fig.)

20404 11. A. J. BOULT, London. **Ore Treatment.** 14 September, 1911.

Arsenic-containing iron ores are prepared for smelting by first roasting a mixture of the arsenic-containing ores and pyrites or pyrites waste, the ores being preferably ground and the roasting effected under oxidising conditions (4 claims.)

1976/12. H. DEBAUGE, Paris. **Purifying Rubber.** Dated, under the International Convention, as 3 February, 1911.

The process of purification which constitutes the subject-matter of this invention, consists in dissolving natural or regenerated rubber in one of its usual solvents and in subjecting the solution to dialysis through a septum of vulcanised rubber, paper, parchment, ebonite, pig's bladder, or the like. (4 claims.)

2137/12. B. E. D. KILBURN. London. **Manufacture of Fuel.** 26 Janurary, 1912.

The invention relates to the manufacture of fuel in the form of paste. 500 gms. of methylated alcohol at 90° Beaumé are mixed with 50—75 gms. of stearate of sodium in a vessel, and the mixture is treated in a water bath until it is completely dissolved. Another 500 gms. of methylated alcohol are mixed in a separate vessel with 50—75 gms. of white soap and about 10 gms. of sodium carbonate and treated in the same manner. The two solutions are then intimately mixed and allowed to stand for a few minutes before being packed. (1 claim.)

2311/12. P. A. NEWTON, London. **Cyanamide.** 29 January, 1912.

The process for isolating cyanamide from crude calcium cyanamide consists, according to this invention, in separating the cyanamide as an insoluble lead compound and removing the lead from the product thus obtained.

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"*Science moves, but slowly, slowly creeping on from point to point.*"—TENNYSON.

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A ROYAL COMMISSION.

WE refer once more to the general question of elementary education so far as it influences the spread of scientific thought in this country.

A general if somewhat spasmodic discussion is still in progress concerning many of the factors involved; and the course this has recently taken indicates that the schoolmaster can hardly hope to settle this important question unaided. It is clearly one of great complexity. It is almost as wide as the interests of life itself.

Take, for instance, the recently expressed opinion of Sir J. Crichton-Browne concerning the result which may be looked for, if " the present remarkable disparity between the hours of sleep common at each elementary school life, and those accepted as necessary in the interests of health is continued." This authority considers that the present state of affairs means " jerry brain building on a large scale, with the prospect of early dilapidation and collapse."

The extraordinary and somewhat cryptic statement recently made by the Headmaster of Eton, that the brain power able to deal with the increasing number of problems (of school life ?) is diminishing, may have some bearing on this statement, and on the system of teaching involved.

One of our leading oculists has recently affirmed that half the deficiencies of eyes are due to early education, and has expressed the opinion, that eight, or ten, is about the right age for reading lessons to begin.

It has been once more pointed out that the phenomenal boy—the pride of the public schoolmaster—very often turns out a failure in after life. A flame blazes up under the influences which are represented by the sixth form, and seemingly burns itself out. The only alternative explanation is that the conditions of actual life are so different from those which the public school prepares the student for, that the boy who most thoroughly adapts himself to it, naturally finds himself unable to take up the running in after life. His natural ability has led him to receive the maximum amount of training under the " system." Those who have escaped this may actually stand a better chance.

Sir Frederick Treves has recently put it on record that—

> " As a schoolboy I should have been classed as indifferent, while my school record as a whole was uniformly unsatisfactory."

Father Benson, the famous Roman Catholic Preacher, has also said—

> " I fear I was regarded at Eton, by my masters, as idle and rather unsatisfactory; and with justice. I was a ' King's Scholar ' there, owing to the admirable teaching I received at my private school, but my school reports from Eton itself were very far from good. I attribute this partly, no doubt, to my own perversity, but also largely to the manner of education that prevailed and still prevails there. I left Eton a very grievous disappointment to my relations, my teachers, and myself."

T. M. Healy, K.C., M.P., even seems to suggest that he owes something to the fact that he left school at thirteen.

The one essential point which comes out when the matter is considered on general lines is that the whole question is beyond the capacity of any schoolmaster to settle. The factors involved are general, medical, scientific, and even literary. That these cannot be dealt with collectively by the average, or even the exceptional headmaster is sufficiently obvious.

No question can be more important to the nation, for we have to hand on to the next generation a knowledge of the things which really matter. Professor Sir J. Dewar has recently deplored the want of scientific knowledge on the part of those who legislate; and pointed out that the alternative of falling back for information on those who have it, indicates a very unsatisfactory state of affairs. Such a system leaves the legislator without the scientific method of thought which goes with scientific knowledge. Our opinion on this matter is well known. We think, more than ever, that the only way of bringing the true meaning of the present position home, must be found in the House of Commons itself.

When regarding the question of elementary education in its widest aspect, it is difficult to come to any other conclusion than that the problems involved are of an exceedingly complicated nature. We agree with A. C. Benson, that a Royal Commission is needed to settle the rival claims of those who wish to alter the present system, and to definitely establish the general lines of future progress.

At the universities and colleges, the complaint is a general one that the " raw material " coming up is unsatisfactory. Beside this statement, a mere discussion whether boys shall learn Latin or Greek seems to savour of the action of Nero when Rome was burning.

Nothing is more certain than that the present system cannot continue indefinitely, unless it receives the support of some such body as that indicated. A Royal Commission must express a definite opinion on the fundamental points involved. Nothing less will settle the unrest which pervades the public mind, and is actually spreading to the boys themselves.

Inefficient education must always be reflected in the thoughts and actions of the people. It is difficult to see any way out of this *impasse* while science remains silent, and leaves questions of this order to be settled on indefinite lines by those who traffic in systems which have lost their value, if not their original meaning.

When the English system is finally worked out, it will probably be a satisfactory one; but there is already sufficient evidence to show that this cannot be accomplished by the schoolmaster working alone. Nor will it be accomplished this side of the Greek Kalends by writing to the newspapers. The matter must be considered on systematic lines and probably in the way indicated.

Chemist or Pharmacist.

It is doubtful whether any point has militated against the recognition of the work and prestige of the chemist in this country more than the uncertainty which exists in the mind of the public concerning the distinction involved in the title of chemist.

The difficulty which exists resolves itself into a distinction between the chemist on the one hand, and the pharmacist, or apothecary, on the other. It is a matter which may be expected to adjust itself to modern requirements and conditions. When the science of chemistry gradually evolved in this country from the earlier work of the pharmacist, no specific difference in title was thought necessary to distinguish the respective workers, and the matter has since remained in what may be regarded as a generally unsatisfactory condition.

To-day, the general title of " chemist " applies equally to the pharmacist and the research chemist. A prefix, such as " research," " technical," or " pharmaceutical," is hardly sufficient to define the present position.

Such a title as "cash chemist" or "store chemist" has led to further confusion; and there can be little doubt, that while the pharmacist gains little by the use of the term " chemist " the chemist proper certainly suffers from its more extended and general use.

Other professions have at least a definite title. The worker in chemistry can claim no such advantage *in this country*. In France and Germany, however, the distinction by name is quite satisfactory from the public point of view. This difficulty has been further accentuated and rendered more difficult by the almost universal use in patent medicine advertisements of the term " chemist," especially when it is associated with the words " and druggist."

The position of the pharmacist, with the public, is a satisfactory one. It would be as well if some steps could therefore be taken to more clearly define the sphere of the chemist's work.

In the colleges themselves, the position may be regarded as normal, and leaving little to be desired. But it becomes a more difficult one when the chemist comes into professional contact with the public. There can be little doubt but that the position involved reacts in an unsatisfactory manner on the quality of the men attracted to the chemical profession by reason of its uncertainty. This is undoubtedly an increasingly important point.

It may, therefore, be argued that in the interests of all those concerned, the respective spheres of work of the chemist and the pharmacist should be more clearly defined. Also, that as things stand, any move in this direction must come from the Pharmaceutical Society.

If the pharmacist would drop the use of the title " chemist," and in this respect place himself in a similar position to the German apotheker, as distinct from the chemiker, or to the French pharmacien, as distinct from the chimiste, the confusion at present existing would be obviated. The old term " apothecary " is a good one, and establishes a link with the past. Even "cash apothecary" sounds well. Its substitution, or that of " pharmacist," for the present general term, which through change in circumstance has lost its original meaning, would be a substantial step in the right direction, and one which would directly correspond with Continental practice. Perhaps the possibility of some such change may be considered in the proper quarter.

* * * * *

With this number Mr. Hatschek's articles on the Physics and Chemistry of Colloids are concluded. They will be followed in the January number by a similar series on Molecular Physics, by J. A. Crowther, M.A., of St. John's College, Cambridge. The Notes on Chemical Research will be followed by a series of articles on Chemical Engineering, by J. W. Hinchley, A.R.S.M., Wh.Sc., who has lectured at the Imperial College of Science and Technology and elsewhere on this subject.

RECENT ADVANCES IN CHEMICAL CRYSTALLOGRAPHY.

By A. E. H. TUTTON, D.Sc., M.A., F.R.S.

ADVANCES in crystallography have been so numerous and weighty during recent years that the subject has become one of much more than merely secondary importance, and issues have been raised of fundamental value, not only to chemistry, but to the physics of solids, issues which involve the very nature of matter itself. Indeed, the latest development, the published details of which have just been received with more than ordinary interest, appears likely to afford the first actual proof of the general accuracy of the atomic theory, involving as it does the photographic record by Röntgen rays of the organised atomic "space-lattice" structure present in crystals. Moreover, the study of crystals has led to practical results of importance in the laboratory, rendering the laborious, prolonged, and destructive processes of chemical analysis superfluous whenever the substance, the chemical composition of which it is desired to ascertain, is available in the condition of good crystals.

It has to be remembered that the crystals of a definite chemical substance are characterised by five properties. They possess (*a*) truly plane faces, which are (*b*) arranged with respect to each other in accordance with a regular plan of symmetry or style of architecture, and are (*c*) mutually inclined to one another at angles which are constant for that same substance, whatever be the relative amount of development of each individual face. (*d*) The number of faces possible on a crystal is not the large number permitted by the system and class (genus and species) of symmetry, but is strictly limited by the Law of Rational Indices, the essence of which is that only such faces are possible as cut off simple integral (that is, expressible by small whole numbers) relative lengths of the imaginary axes which serve to define their geometrical positions in space.

This remarkable law, in itself a proof that solid matter is of discontinuous, atomic or molecular structure, may be clearly brought home to the mind by instancing the fact that there are not an infinite number of pyramids possible in any particular system of symmetry—ranging from very low ones with vertical axis nearly zero and lateral axes relatively large, to very tall pyramids with large vertical axis and very short lateral axes—but that only a few pyramids are possible, and a very few as a rule actually present, namely, those which have whole-number intercepts on the axes such as 1, 2, 3, 4, 5, and rarely as much as 6. Thus the series of pyramids proceeds by definite steps, as if indeed the structure were built up of bricks or blocks of tangible size, the pyramidal angle depending on how many bricks there are fewer in each layer as the pyramid is erected. The bricks being only of the size of the parallelepipedal unit cell of the space-lattice—which may include only a single chemical molecule, or at most a very few molecules—the step-like serrations of the surface are invisible to our eyes. (*e*) In the cases of those closely related substances, the members of "Isomorphous Series," first made known to us by Mitscherlich, the literal interpretation of the term "isomorphous" has been definitely proved by the writer, by the most careful measurement of the angles on crystals of high perfection, to be incorrect, in all other cases than those of cubic crystals (in which the perfect symmetry itself involves equality of angles). For the different members of the series exhibit slight differences in their interfacial angles, which may be only a few minutes in the more symmetrical systems but may amount to as much as three degrees in the less symmetrical systems; and the amounts of these differences follow the order of progression of the atomic weights of the elements of the same family group which by their interchangeability produce the series.

In addition to these five fundamental facts—which have no element of theory or hypothesis about them, but are purely experimental, and as such are incontrovertible — there may be adduced three others, which, while not derived originally from experiment but from geometrical and mathematical considerations, afford a wonderful explanation of the experimental facts. Indeed one of them has just received the remarkable direct experimental confirmation already alluded to. This is that (*f*) the structure of a crystal is of the nature of a "Raumgitter" or "space-lattice." Such a space-lattice would obviously be formed if each of the "bricks" in the edifice were represented by a central or similarly situated point, and these points joined by straight lines parallel to the edges of the bricks. There are fourteen possible types of space-lattice. which were first described by Frankenheim and further substantiated by Bravais. We may regard each point either as the centre of gravity of a chemical molecule, or more generally small group of molecules (the "brick") of the substance forming the crystal, or as some particular atom in the molecule or group, so long as the corresponding atom is taken in every molecule or group of the assemblage. The next fact (*g*) is that the stereometric arrangement of the atoms in the molecule, and that of the few molecules forming the group with respect to each other, in the more general case when grouping occurs (including cases in which the atoms composing adjacent molecules are not identically orientated, but may be arranged in mirror-image fashion), and consequently the arrangement of the chemical atoms in the whole crystal substance may be homogeneously in accordance with any one of the 230 different possible types of homogeneous structures which have been shown capable of existence by the combined labours of Sohncke, Schönflies, von Fedorow, and Barlow. We have further the geometrical fact (*h*) that there are only thirty-two possible types of crystal symmetry, known as classes, and this is so far an experimental fact that already thirty-one of these classes or species have been observed to exist in the crystals of definite chemical substances. Moreover, each of the 230 point-systems possesses the symmetry of one or other of these thirty-two classes, and the latter are grouped into the seven systems of crystal symmetry, the system being thus the genus, while the class is, as it were, the species ; these seven systems are the cubic, trigonal, tetragonal, hexagonal, rhombic, monoclinic, and triclinic systems. Of the fourteen space-lattices of Bravais and Frankenheim, three are of cubic symmetry, two are tetragonal, two are trigonal (one of them being also hexagonal), four are rhombic, two are monoclinic, and one is triclinic. The space-lattices always possess the full (holohedral) symmetry of the systems to which they belong, and it is undoubtedly the space-lattice which governs the system, the crystal angles, and the conformity with the law of rational indices.

Assuming the accuracy of these now well established geometrical results, it has been possible actually to calculate the relative sizes of the elementary cells (the molecular or polymolecular " bricks ") of the space-lattices of a series of isomorphous compounds ; for in these we are certain that the style of architecture is the same. This is done by combining a knowledge of the relative density, and therefore (by dividing this into the molecular weight) of the molecular volume, with that of the crystallographic axial ratios. Such dimensions were called " topic axial ratios " by Muthmann and " molecular distance ratios " by the writer. For we do not know how much is matter and how much is space in the parallelepipedal cells, and it is better to consider the edges of the cells as representing the distances apart of the centres of gravity of the molecules or molecular groups along these directions.

That there is fundamental truth in this idea of molecular distance ratios is experimentally proved by two interesting facts, namely, that parallel growths of one crystalline substance on another have been shown by Barker to occur only in the cases of substances which have very nearly identical molecular distance ratios, and that the starting of crystallisation in a supersaturated solution, in the metastable condition of Ostwald and Miers, only occurs when it is impregnated with crystal germs (floating in the air) of a substance which, if not identical with that present in the supersaturated solution, is one possessed of almost identical molecular distance ratios ; even an isomorphous substance is not effective if the distance ratios are considerably different. Further, the phenomenon of " vicinal faces " has been shown by Miers to be dependent on the space-lattice structure of crystals.

From the foregoing it will have become obvious that there is a very great body of evidence that the structure of a crystal is of the nature of a space-lattice, and it will have become equally clear that the space-lattice is intimately related to the chemical molecule ; for each point or node of the lattice directly represents in the simpler cases such a molecule, and in the more general case a group composed of a small number of molecules, arranged so that the whole number of atoms present occur in conformity with a Sohncke, von Fedorow or Barlow point-system. It must be further apparent that it is the regular laying down of the molecules, like the bricks of the builder, one by one in regular sequence during the act of crystallisation—from a supersaturated solution, from the state of fusion, or by the condensation of the vaporised substance—that the crystal edifice is erected. The fact that the molecules are all deposited either similarly as regards orientation (a molecule having clearly a shape dependent on the stereometric arrangement of the atoms composing it), or more generally according to some regular definite plan, including that of mirror-image symmetry, ensures that the whole atomic arrangement shall be in accordance with one or other of the 230 point-systems ; and in the solid structure thus produced, a homogeneous assemblage of chemical atoms, the identity of the original molecules may be obscured. Yet it is obviously still there, each hypothetical point of the space-lattice representing the cluster of atoms forming the chemical molecule or group of molecules laid down. In simple cases, such as that of zinc blende, ZnS, for instance, to which further reference will subsequently be made, a single space-lattice characterises the whole crystal ; and as any atom of the molecule or group (a group in the case of zinc blende) may be taken as its representative point, provided the analogous atom is similarly taken in every other molecule or group, the space-lattice may be in this sense referred to and considered at the atomic space-lattice.

Hence, in much of the recent work on crystal structure in its relation to chemical constitution the molecule has been ignored, and the crystal considered only as an assemblage of chemical atoms. The valency theory of Pope and Barlow thus considers it, each atom being supposed to be represented by its sphere of influence, the dimensions of which are assumed to be proportional to the fundamental chemical valency of the element of which the atom is composed. These atomic influence spheres are presumed to approach into actual contact on crystallisation, and indeed to be pressed together until they practically fill space by their contact, all interstices being eliminated and the spheres deformed into polyhedra. The identity of the molecule thus becomes concealed, and it has even been suggested that on re-solution, re-fusion, or volatilisation, the same atoms may not form the same identical molecules as formerly. Whether this be so or not requires much more work to be done on the nature of the act of crystallisation, and the work of Lehmann on the so-called liquid crystals has at any rate proved conclusively that the chemical molecule has a much more powerful individuality and resistant identity than it had for some time been the custom to attribute to it.

One of the most difficult matters connected with descriptive crystallography has been to determine the correct mode of setting up the crystal for description, and the proper choice of the "parametral" face determinative of the relative lengths of the crystallographic axes. For in the systems of lower than cubic symmetry several alternatives are usually presented; and even although in the trigonal, tetragonal, and hexagonal systems the vertical singular axis is clearly indicated, the length of that axis in relation to that of the lateral axes is a matter of choice, dependent on which set (" form ") of faces inclined to both vertical and lateral axes is taken as the parametral one fixing the unit lengths of the axes. One of the most serious criticisms to which the theory of Pope and Barlow has been open is that in many cases they, in the absence of any trustworthy guide, selected that one of several alternative settings which fitted in best with their theory. Now the correct choice is obviously a matter of extreme and indeed fundamental importance, for a true perception of the nature and dimensions of the space-lattice, and the discovery of some infallible method of ascertaining the correct setting had become a most urgent matter. Such a discovery, embodying a great advance, appears to have been made at length by von Fedorow. For it enables a valid comparison to be made of the symmetry, and of the axial dimensions and inclinations known as the "crystallographic elements," of definite crystallised compounds of all kinds, and thus a tabular record to be compiled of the crystallographic constants of all substances which crystallise adequately well the number of which is now immense.

The conception of crystal structure by von Fedorow is somewhat akin to that of Pope and Barlow, but instead of dealing with the structural units by means of their "spheres of influence," he considers them as parallelohedra right away. He shows that there are four types of parallelohedra which satisfy his conception of the nature of crystals, all four being capable of filling space without interstices. They are the cube, the rhombic dodecahedron, the cuboctahedron, and the hexagonal prism. The first three are of cubic symmetry, and the fourth is obviously hexagonal, and all four may be homogeneously deformed into parallelohedra of the lower systems of symmetry without ceasing to fill space when packed together. Hence, he concludes that all crystal structures are of either cubic or hexagonal type, when the meaning of these terms is extended to include their derived deformed varieties. If we replace each parallelohedron by a central point we obtain either one of the fourteen Bravais space-lattices or one of nine other simple Sohnckian point-systems compounded of interpenetrating space-lattices. All the twenty-three parallelohedra are arranged parallelwise.

These parallelohedra of von Fedorow, however, are not identical with those of Pope and Barlow; for the latter represent the chemical atoms, whereas those of von Fedorow are either molecular or polymolecular, being in the less simple cases made up of a small number of identically similar polyhedra termed by von Fedorow "stereohedra." These latter then represent the chemical molecules, and they may be differently orientated, mirror-image-wise for instance; the analogous points representing these stereohedra, one point for each stereohedron, constitute one of the sixty-five Sohnckian regular point-systems.

Now it is an experimental fact that those faces of crystals which grow most slowly, and are therefore the best and most extensively developed when the conditions of growth are ideal, are those along which the points of the space-lattice are most densely strewn. The correct "setting-up" and proper axial system of a crystal is consequently conceived by von Fedorow to be that for which the primary faces (those parallel to the crystallographic axial planes and also those which cut off unit lengths along the axes) are such as possess the maximum reticular density. Observations of any tendency to show angles near 90° or 60° are also taken into consideration, as affording evidence of cubic or hexagonal habit. The development of cleavage is a further most valuable aid, for in crystals of the type termed positive by von Fedorow, in which the vertical axis is longer than the lateral axes, the greatest reticular density and maximum cohesion occur in the basal plane perpendicular to the vertical axis, and the crystal both develops a tabular habit and cleaves parallel to the basal plane; in negative crystals, where the vertical axis is the shorter, the reverse holds, and a prismatic habit and cleavage are developed. When the ideal conditions for growth are not realised, however, fortuitous habits are developed of a different nature, hence, calculations of reticular density should be made for all of the few possible settings, and that decided upon for which the primary faces have the maximum reticular density.

Having thus settled the proper setting and axial scheme, and determined by goniometrical measurement the crystallographic elements (including the exact relative axial lengths), of a particular crystalline chemical substance, they are recorded in a table, in which all substances for which such accurate data are available are arranged in the order of their systems and classes of symmetry, those belonging to each class being arranged in the order of magnitude of their crystallographic elements. The latter have been reduced by von Fedorow to what he considers their simplest terms, a "form symbol" in each case. This is not at all necessary, however, and to some may appear as a complication, the ordinary crystallographic elements, the axial angles and axial ratios, being preferred. The two or three-circle goniometer is used by von Fedorow, so as to obtain all the angular data necessary with a single fixing of the crystal on the wax of the crystal-holder; the results are graphically recorded on a stereographic net, and most of the calculations are carried out graphically with the aid of the net or a Nikitin's porcelain hemisphere. Again, all this is merely a means for rapid work, and the more absolute but longer methods of ordinary crystallographic practice may be preferable, and in the long run will have to be carried out by the most careful experimenters in order to obtain the highest accuracy for these important constants.

The remarkable table already prepared by von Fedorow comprises no less than ten thousand substances, the crystals of which have been adequately measured by recognised crystallographers, and the elements of which have been reduced by von Fedorow to their form symbols. Hence, if a crystal of any one of these substances be placed in the hands of a competent observer, who is left in ignorance of its chemical composition, he has only to investigate it in the manner just described, and to calculate its form symbol or "elements," when its composition will at once be revealed on reference to the table, the constants obtained being found to tally exactly with those of one of the substances in the table.

In order to test the value of this new crystallographic mode of chemical analysis, a number of crystallographers were invited to send well crystallised specimens of substances they had investigated to Professor von Fedorow in St. Petersburg, without the name or formula of the substances appearing, each being marked with a distinguishing number only. The writer had the pleasure of sending several such test samples, and in every case the substance was identified without difficulty by Professor von Fedorow, even although some of them were very complicated organic compounds. In fact, in the cases of practically all the numerous substances submitted by colleagues to Professor von Fedorow, in which the crystals arrived in good condition, the substances were identified, the only failures being partial ones, where a substance was mistaken for an isomorphous one, owing to the development not having been sufficiently perfect to enable a discrimination to be made between angles so close to each other.

Hence, there can be no doubt that this new work marks an important advance. With the table of Professor von Fedorow, which it is hoped will shortly be published in full, and the admirable "Chemical Crystallography" of Professor von Groth, which includes details of the measurements of every substance yet adequately investigated crystallographically, information will be available for the universal employment of this new crystallochemical analysis, not necessarily by the particular methods of Professor von Fedorow, but by the ordinary methods of crystal measurement.

And now, coming at this moment when the space-lattice has proved itself of such paramount importance, it is of the greatest possible interest that the space-lattice has at last been experimentally proved to be a real fact. Dr. M. Laue, associated experimentally with Herren W. Friedrich and P. Kripping,[1] has carried out in the physical laboratory of Prof. A. Sommerfeld, in Munich (having been attracted to the subject by the work of the latter[2] on the Diffraction of Röntgen-rays), an investigation of the effect of passing a narrow cylindrical beam of Röntgen-rays perpendicularly through a plate of zinc blende, ZnS, and receiving the transmitted rays also normally on a photographic plate. On developing the latter a geometrical figure of spots is obtained, arranged symmetrically around a larger central spot due to the direct rays, the most prominent set taking the form of a square with four spots at regular intervals forming each side. The figure, in short, exhibits perfect (holohedral) cubic symmetry, that of the highest class 32 of the cubic system, although zinc blende belongs to the class 31, next lower in the system, the hexakis-tetrahedral (hemihedral) class. This fact affords a perfect proof that the figure is due to the space-lattice structure of the crystal.

Zinc blende may be conceived in accordance with the definition of crystal structure given by von Groth (based on Sohncke's later work, and that of von Fedorow and Barlow), and with the suggestions of Pope and Barlow[3] (not dependent on their valency theory) to be composed of two interpenetrating regular point-systems composed respectively of zinc atoms and of sulphur atoms; these in turn are built up of a number (sixteen according to Pope and Barlow) of interpenetrating space-lattices, each composed of identically situated atoms of the same element. All the space-lattices are identical, and give the same parallelepipedal cell, a cube of equal dimensions. Zinc blende is thus characterised by a single cubic space-lattice, formed by taking one atom from each group of molecules (16), which, together, produce the complete point-system, and the photograph of spots would thus appear to correspond to the *Atomic Space-lattice* formed by similarly situated atoms of the same chemical element. Dr. Laue considers that it is the space-lattice of the metallic zinc atoms which affords it. In any case, however, the photograph is due to the space-lattice, and thus the assumptions of crystallographers are wonderfully confirmed by direct experiment.

Action of Fused Potassium Hydroxide.—Some remarkable results have been obtained by Le Blanc and Weyl, when examining the action of this substance on certain elements in an atmosphere of nitrogen. At 400° C. all the absorbed water was driven off from the fused mass. Up to 660° C. no dissociation but slight volatilisation took place. At this temperature nickel, cobalt, and iron were attacked without the evolution of water hydrogen or potassium. With chromium and tungsten both the latter were evolved. Silicon reacted violently even at 400° C. with the evolution of hydrogen. In the case of sodium the ultimate products were sodium oxide, hydrogen, and potassium which was volatilised. The reaction in this case involves an intermediate stage which is indicated. The original communication must be referred to for further information on this point.

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[1] "Sitzungsberder Kön. Bayer, Akad. der Wiss., Math. Phys. Kl.," 1912, page 303.

[2] *Ann. der Physik.*, 1912, 38, 3, 473.

[3] *Journ. Chem. Soc. Trans.*, 1907, 91, 1152, 1171 and 1178.

THE INVESTIGATION OF THE CHEMICAL ACTION OF BACTERIA.

By ARTHUR HARDEN, D.Sc., F.R.S.

ONE of the most striking characteristics of many groups of bacteria is the profound chemical changes which they are capable of setting up in the sugars and higher alcohols. Advantage of this has been taken from a very early date for the manufacture of such substances as lactic and butyric acids on the commercial scale, and the aid of bacteria has been invoked in the most recent developments of chemical industry, the production of acetone, of fusel oil, and ultimately of rubber. Apart from these somewhat limited commercial applications, the subject of the chemical action of bacteria has been largely studied from the qualitative point of view as an aid to the discrimination of the various species of these organisms, and in this way a large store of information has been acquired as to the production of acid or gas from a considerable number of sugars, alcohols and glucosides. Quantitative work on the subject has been much less frequent, but is gradually increasing both in scope and accuracy. One of the earliest pioneers in this branch of the enquiry was Fitz, who in the seventies of last century made a large number of quantitative experiments, especially on the butyric type of fermentation. In many cases the actions studied by him were due not to a single organism, but to a mixture such as occurs in cow-dung or in a saccharine fluid exposed to infection from the air. Such mixed fermentations are well worthy of study, since the natural changes produced by bacteria are almost invariably brought about in this way. They are, however, much less valuable for the investigation of the mechanism of the action, a subject which requires the strictest attention to the purity of the cultures employed. Fitz was followed by P. F. Frankland, who worked throughout with pure cultures, and since then the subject has been pursued by a fair number of workers, who have usually devoted themselves to the examination of some special group of organisms—the cellulose fermenters, the organisms producing butyric acid, the intestinal organisms of the coli and typhoid groups, etc.

As the result of such work it has been found possible in many cases to construct a fairly complete balance sheet for the organism showing the products formed from any given substance. Qualitatively the substances resulting from the bacterial decomposition of a compound such as glucose are comparatively limited in number, but vary considerably for the different species of bacteria. Thus organisms of the butyric group produce butyric acid, butyl alcohol, acetic acid, ethyl alcohol, lactic acid and a gaseous mixture of carbon dioxide and hydrogen; on the other hand, the true lactic acid bacteria produce practically nothing but lactic acid, whilst the intestinal bacteria form alcohol, acetic and lactic acids and either formic acid or a mixture of carbon dioxide and hydrogen. Another group produces a large proportion of 2·3 butyleneglycol and a small amount of acetylmethylcarbinol, $CH_3 . CO . CH(OH) . CH_3$, along with alcohol and small amounts of acetic and lactic acids. Succinic acid is an almost invariable accompaniment of the action of bacteria on glucose. Whether its origin is invariably the amino-acids of the protein, as in the case of that formed by yeast, is not certain. In any case, it is sometimes formed ultimately from the sugar, since it is produced even when the only nitrogen supplied is in the form of ammonium salts.

Faced with the multiplicity of products, which often results from the action of a single organism, the investigator is at once led to enquire how such a complex chemical transformation is brought about.

The fundamental question, whether the change is due to the action of enzymes or to the general activity of the living organism, may be taken as settled in favour of the former alternative. Since Buchner's work on the zymase of yeast in 1897, he has also shown that at least two species of bacteria produce their characteristic effects by means of enzymes. One of these was a lactic acid forming organism, and it was found still to convert sugar into lactic acid after it had been killed and dehydrated by means of acetone. Direct proof of the enzymic nature of the changes produced by bacteria is, however, very difficult to bring, owing to the small weight of bacteria to be obtained, and such decompositions as those typical of the organisms of the butyric or intestinal groups have not yet been actually demonstrated to be of this character, although it is a fair assumption that such is in reality the case.

So much being taken for granted, it remains to ascertain the number of enzymes concerned and the chemical process involved in the action of each to these. Very little progress has so far been made towards the solution of either of these problems. Several suggestions have been made as to the chemical process involved in fermentation changes. Hitherto, however, experimental treatment of the question has been almost entirely confined to the alcoholic fermentation of sugar by yeast, and even in this more accessible region no definite conclusion has yet been reached. As regards bacterial action, the most suggestive hypothesis at present in the field is that of Magnus Levy, according to which the production of butyric acid and similar substances is preceded by the formation of a two-carbon compound, acetaldehyde, which then undergoes condensation and intramolecular change or simultaneous reduction and oxidation.

$$CH_3.CHO + CH_3.CHO = CH_3.CH(OH).CH_2.CHO$$
$$= CH_3.CH_2.CH_2.COOH.$$

Direct proof of this change is still wanting, but there is a strong probability that some such transformation occurs, and it has been recently shown (Harden and Norris), that *B. lactis ærogenes* is capable of building up butyl derivatives both from acetaldehyde itself and from ethyleneglycol. Fernbach moreover has observed the direct production of dihydroxyacetone, $CH_2(OH).CO.CH_2.OH$, from glucose by the action of *Tyrothrix tenuis* (Duclaux), and it is suggested that both in alcoholic and bacterial actions this substance may play an important part as an intermediate compound.

With regard to the other problem, the number of enzymes concerned in each fermentation, the only evidence until recently available was extremely indirect and drawn from the molecular ratio of the products formed. Thus many of the intestinal organisms produce alcohol and acetic acid from glucose in equimolecular proportions, and it seems difficult to resist the conclusion that in such cases these substances are the result of a single enzymic change.

The hope of more light on this interesting question is afforded in a somewhat unexpected manner by observations on the variation of bacteria when cultivated under certain conditions. It has now been placed beyond doubt that the biochemical properties of many bacteria may undergo marked variation. Thus the *B. typhosus*, which normally does not ferment lactose, was found by Twort to have acquired this property after a long-continued series of cultivations on a medium containing this sugar, and many other similar examples are known.

In the course of experiments on this fascinating subject, Penfold made the curious and unexpected discovery that *B. coli communis* and some of its congeners undergo a remarkable process of selection or variation when cultivated in the presence of sodium chloroacetate. This substance acts as a moderately powerful inhibitant, the presence of 1—2% of it in nutrient agar entirely preventing the growth of the organism. When, however, it is applied in lower concentration, it is found that this inhibition is selective. Under suitable conditions, when a plate is inoculated with about 100,000 bacteria, a large number of very small colonies develop, accompanied by a small proportion of large ones, whereas at a somewhat higher concentration, the sole growth on the plate consists of a few large colonies, instead of the almost uniform layer of growth, which would result in the absence of the chloroacetate. Cultures made from these large colonies are quite resistant to the concentration of chloroacetate on which they have been produced, and grow in its presence just as freely as in its absence.

When these colonies were tested as regards their fermentation reactions, the surprising observation was made that many, but not all, of them had also undergone change in this respect. A certain proportion of the colonies no longer produced any gas from glucose, although they continued to form acid from this sugar and still produced both acid and gas from mannitol.

The most natural conclusion to be drawn from this observation is that some one or more of the enzymes of the bacillus have undergone modification at the same time as its power of resisting sodium chloroacetate.

Now, so far as is known, the production of gas from glucose by *B. coli* is due to the formation and subsequent decomposition of formic acid or a formate. Hence, the first point to be decided was whether the bacillus had lost the power of decomposing formates. This was not found to be the case—the selected organism decomposed formate quite as freely as the original strain. It follows that in all probability it is the power of producing formic acid which has been modified. The chemical action of organisms of the coli group happens to be known. The products consist of alcohol, acetic and lactic acids, carbon dioxide and hydrogen, approximately in the proportions corresponding to the following equation, together with a little succinic acid:—

$$2\ C_6H_{12}O_6 + H_2O = 2\ C_3H_6O_3 + C_2H_4O_2 + C_2H_6O +$$
$$2\ CO_2 + 2\ H_2.$$

Actually the carbon dioxide and hydrogen are produced in relatively smaller amount, and the alcohol and acetic acid often in somewhat larger. The quantitative examination of the products formed by the selected organism might therefore be expected to indicate the nature of the modification which has occurred. Preliminary results have already been obtained in this direction (Harden and Penfold) which indicate that the loss or diminution of the power to produce gas is accompanied by a diminution in the amounts of alcohol and acetic acid and an increase in the amount of lactic acid. In other words, there appear to be at least three enzymes concerned in the decomposition of glucose by this organism:—

(1) A lactic acid producing enzyme.
(2) An enzyme which forms acetic and formic acids and alcohol.
(3) An enzyme which decomposes formic acids.

Of these, No. 2 is present in relatively smaller amount in the selected organisms.

Further, since the selected organism still attacks mannitol with production of gas, it is probable that still another enzyme, or set of enzymes, is concerned in the attack of this substance.

It will be seen from the foregoing that this method of experiment suggests interesting possibilities in several directions. It seems likely, as instanced above, to afford an invaluable means of analysing the complex action of micro-organisms into simpler enzymic reactions. Moreover, it opens up a vision of the scientific or technical bacteriologist of the future in the possession of a series of bacteria specially selected for specific chemical purposes.

THE CONSTITUTION OF PORTLAND CEMENT.

By CECIL H. DESCH, D.Sc., Ph.D.

THE artificial product known as Portland cement has, during the last half century, established its position as the most valuable and trustworthy of all cementing materials for structural work. The process of manufacture has followed a course of gradual development on empirical lines, but scientific investigation has had an important share in the remarkable improvement of quality which has accompanied the increased use of Portland cement for large works in concrete and reinforced concrete. It is characteristic of the material that, whilst satisfactory specimens from different sources may differ considerably in composition, a very slight variation in the product of a single works may change a valuable into a useless and even dangerous product. This peculiarity depends on the fact that the cement is not in a condition of chemical equilibrium. The temperature of manufacture does not exceed 1,500° C., which is far below the melting point of the reacting materials. Consequently, the reaction between the lime, silica and alumina, which are the essential components of the cement, takes place in a mass which is mostly solid, and the short time during which heating is continued is not sufficient to allow the chemical reactions to proceed to completion. In any one works, the conditions of heating are sensibly constant, and a slight variation of composition leads to the presence of an excess of one or the other constituents in the product, whilst the conditions in different works may show wide variations in the approach to chemical equilibrium.

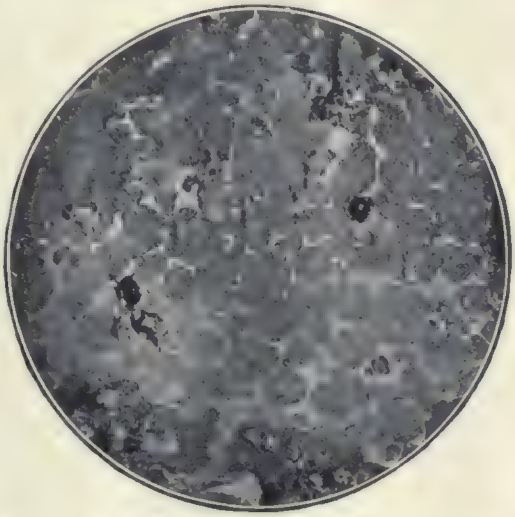

FIG. 1.—PHOTO-MICROGRAPH OF PORTLAND CEMENT CLINKER BY REFLECTED LIGHT, AFTER ETCHING WITH DILUTE ACID.

It is evident that an ultimate chemical analysis of cement cannot, in the absence of further information, serve to characterise the product, and a satisfactory process of proximate analysis by chemical means has not yet been devised. Its absence, however, is supplied to a large extent by the method of microscopical examination, by means of which the proximate constituents may be distinguished and identified. For this purpose cement in the form of powder is generally less suitable than the unground clinker as it leaves the kiln. Two methods are available for the preparation of clinker for the microscope. The first is identical with that used in the study of rocks, namely, the grinding of sections sufficiently thin to be transparent, which are then examined by transmitted light. This method has great advantages, as polarised light may be employed, and the constituents may be identified by their optical properties as well as by their external form. In practice, however, it is hampered by the porosity and brittleness of the clinker, which render it extremely difficult to cut a section so thin that the optical characters may be determined with accuracy. The second method is more easily applied, and is capable of exhibiting the structure very clearly. It consists in treating the clinker in the same way as a specimen of metal, by grinding and polishing a flat surface and etching with a chemical reagent.[1] Fig. 1 represents a section of ordinary cement clinker, polished in this manner, and etched lightly with very dilute hydrochloric acid. The dark crystals, which compose the principal part of the clinker, are those of the constituent termed *alite* by Törnebohm, and now known to be the essential active material, the reaction of which with water constitutes the setting of the cement. The light areas are secondary constituents, which hydrolyse slowly or not at all, whilst dark gas-cavities are also to be seen in the photograph.

It has long been known that the essential compound present in Portland cement is a calcium silicate, which is not identical with any naturally occurring mineral. To this compound Le Chatelier attributed the composition 3 CaO, SiO_2, and it has been found that artificial products of this composition actually possess the properties of a cement. A question arises, however, as to the part played by the alumina which is an invariable component of the clinker. Schmidt and Unger succeeded in isolating crystals of apparently pure alite, which were apparently homogeneous, behaved as a cement, and contained alumina as well as lime and silica. This would indicate that alite was either a calcium alumino-silicate of uncertain constitution, or a solid solution of a silicate and an aluminate. The recent attempt by W. Asch and D. Asch[2] to assign definite formulæ to cements must fail in view of the fact, overlooked by those authors, that the clinker is microscopically heterogeneous, and must contain crystals of several different species.

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[1] See the author's "Chemistry and Testing of Cement" (London, 1911).

An exhaustive study of the ternary system—lime-alumina-silica, within which the cements and blasts-furnace slags fall, has been undertaken in the exceptionally well-equipped Geophysical Laboratory in Washington, and a preliminary account of the results has now been published.[3] Previous studies in the same laboratory of the respective binary systems have resulted in a very satisfactory knowledge of the binary compounds which are formed, which include three calcium silicates, four calcium aluminates, and only one aluminium silicate. To these the survey of the ternary system has added two ternary compounds, already known in the form of native minerals, anorthite and gehlenite. The method of preparation being in all cases that of fusion of the component oxides, it was not to be expected that many of the naturally occurring calcium alumino-silicates would appear in the system, as only those phases are represented which are stable in contact with the liquid phase.

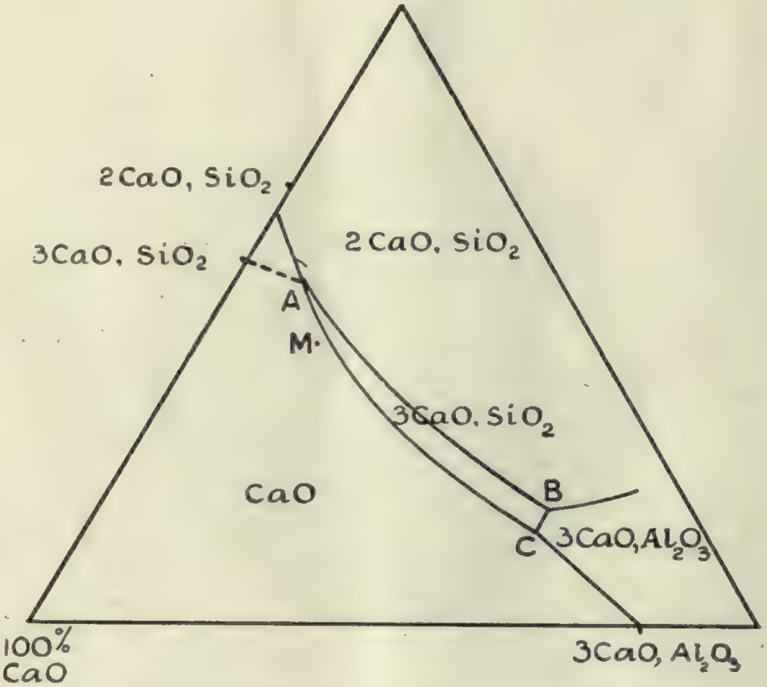

FIG. 2.—EQUILIBRIUM DIAGRAM OF PORTLAND CEMENT.

As the composition of all varieties of Portland cement falls within certain limits, only a portion of the ternary system is of interest from this point of view, and it is unnecessary to discuss the remainder of the system. Fig. 2 shows, in the usual triangular form of diagram employed in the representation of ternary systems, the constitution of mixtures containing more than 50% of lime, and each field is lettered with the formula of the compound which solidifies first when a mixture represented by a point within that field is allowed to cool. Two such complete fields, and portions of two others, are shown in the same illustration. The large area to the left corresponds with the primary separation of lime, the narrow crescent-shaped area with that of tricalcium silicate, and the two partial fields with that of dicalcium silicate and of tricalcium aluminate respectively. Tricalcium silicate is not stable at its melting point, and the crescent-shaped field therefore does not extend to the left-hand limit of the diagram. The presence of alumina increases its stability.

A typical Portland cement is represented by the point M, and suitable mixtures for the purpose must lie in its immediate neighbourhood. The process of crystallisation of a molten mixture then takes place as follows. If the point M lies between the lines AB and AC, tricalcium silicate crystallises first; then a mixture of the two silicates crystallises as the composition of the still liquid portion travels along the line AB, until at the point B a ternary eutectic mixture solidifies at constant temperature, the constituents of which are:—

$3\ CaO, SiO_2$
$2\ CaO, SiO_2$
$3\ CaO, Al_2O_3$.

If, on the other hand, the point M lies within the lime area, the crystals which separate first are those of lime, but the quantity of such is small, and at a lower temperature they react with the still liquid portion to form tricalcium silicate, and the subsequent process is the same as before. Should the quantity of lime be so large that crystals of it remain uncombined in the final product, a dangerous cement is obtained, as such crystals undergo hydration very slowly, and so cause expansion after the setting of the cement is complete. The limits within which the absence of free lime may be assured may thus be determined by a study of the equilibrium diagram.

It is interesting to note that Shepherd and Rankin did not observe the formation of solid solutions of any of the components. This suggests that Schmidt and Unger were mistaken in regarding their synthetic alite as homogeneous, and that alite is really tricalcium silicate.

A recent worker, E. Jänecke,[4] has examined similar mixtures by the thermal method, and has arrived at the conclusion that a further ternary compound exists, identical with alite, and having the composition $8\ CaO, 2\ SiO_2, Al_2O_3$. Whilst it is claimed that this substance presents the thermal and optical characters of a definite compound, Shepherd and Rankin, assisted by the optical investigations of F. E. Wright, maintain that mixtures of this composition, however they may be fused and allowed to solidify, contain at least two micrographic constituents. In view of the remarkable manipulative skill and experience of the Washington workers, very great weight must be attached to their opinion, and the balance of evidence must be held to be against the proposed formula.

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[2] "Die Silikate" (Berlin, 1911).

[3] E. S. Shepherd and G. A. Rankin, *Zeitschrift für anorganische Chemie*, 1911, 71, 19.

[4] *Zeitschrift für anorganische Chemie*, 1911, 73, 200.

As has been mentioned above, Portland cement is not at present prepared by fusion, but by heating to the sintering point only. It is not, therefore, to be expected that the constitution of the clinker will correspond exactly with that indicated by the theoretical diagram. Nevertheless, the most probable constituents are those just mentioned, tricalcium silicate being the essential reactive material, whilst tricalcium aluminate is concerned in the initial set, and dicalcium silicate probably plays a part which is very incompletely understood in modifying the setting and hardening properties of the cement. On the other hand, dicalcium silicate, unaccompanied by the more basic compounds, is the active constituent of cements prepared from blast-furnace slags, which are always poorer in lime than the true Portland cements.

Whilst lime, silica and alumina are the invariable components of calcareous cements, and in all probability the only essential oxides, ferric oxide and magnesia derived from the raw materials are almost always present in varying quantity. It is generally assumed that ferric oxide replaces alumina, and that magnesia replaces lime, but the effect of the substituting oxide is by no means identical with that of the oxide which is replaced. The effect of these minor components on the equilibrium yet remains to be determined. Iron is deliberately excluded from the "white Portland cement" now prepared for decorative purposes from pure limestone and non-ferruginous clay.

Alkalies and sulphates, which are present in small quantities only, exert an influence on the properties of the cement which is out of all proportion to their quantity, and is undoubtedly of a catalytic nature. The action of sulphates is known, the presence of these compounds retarding the setting of the cement, and gypsum is deliberately added in small quantities for this purpose to Portland cements made by the rotary process, these products having otherwise a tendency to set too rapidly. Alkalies influence the properties in a much more obscure manner, but it is probable that they play a part in the changes undergone by many cements during storage, affecting the rapidity of setting to a very remarkable degree.

It may appear that the question of the exact formulæ of the chemical compounds contained in cement clinker is a purely academic one, of interest to the physical chemist and perhaps to the mineralogist, but of little importance to the manufacturer or user of cement. Such a view is, however, a short-sighted one. It is true that modern Portland cement is a first-class product, that it has been brought to its present quality by empirical methods, and that chemical analysis, supplemented by physical tests, serves to control the uniformity of the product, but finality has not been reached, and the quality is susceptible of further improvement. This may be effected by increasing the proportion of the active constituent, alite, in the cement, if the supposition that the remaining constituents serve merely as inert ballast be true. The object is to obtain on hydration the largest possible quantity of the colloidal monosilicate, the drying and hardening of which gives to mortar its mechanical strength, whilst the chemically inactive material required to prepare a mortar is much more cheaply added in the form of sand than as an inert loading present in the cement itself. Further, it is desirable that a cement should not undergo slow changes in its setting time and other properties during storage, but that the properties of the freshly-ground clinker should remain perfectly constant as long as the cement is stored in the absence of moisture. A knowledge of the constitution of the material should be of great assistance in making such further advances. The problem has become too complex for mere guessing and rule-of-thumb improvements, and we may expect the scientific investigation of clinker to assume great importance in the future development of this great industry. We have but to glance at the parallel case of the metallurgy of alloys, and to observe the manner in which it has been influenced for good by the development of scientific metallography, in order to realise that, in operations which are essentially applications of physical chemistry, pure science and technical practice must go hand-in-hand if further valuable advances are to be made in the industry.

Formylated Cellulose.—Edward C. Worden has recently given an historical summary, with bibliography, of the esters of cellulose, before the Society of Chemical Industry. He points out that the high cost of acetic anhydride has militated against the commercial exploitation of cellulose acetates. The search for other esters which, while at the same time uninflammable and non-explosive, could still be produced at a figure admitting of direct commercial competition with nitrocellulose the industrial possibilities of formylated cellulose have received the serious attention of chemists. The fact that in the formylation of cellulose no counterpart of acetic anhydride—the most expensive constituent of the acetylating mixture—is required is the principal factor for the great activity displayed in this field at present. The author thinks that it is probable that in the near future the cellulose formates may be produced in unlimited amounts commercially at a cost at least not in advance of the present cost of nitrocellulose, starting with the same source of cellulose.

The author describes his own attempts, which so far have not been successful, in obtaining flexible coherent films of formylated cellulose. There can be little doubt that an industrial application will follow when this problem has been brought to a successful issue.

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CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

OILS, FATS AND MILK PRODUCTS.

By E. RICHARDS BOLTON and CECIL REVIS.

To the practical man the mode of action of Twitchell's reagent is perhaps of little interest, but Grimlund (*Zeits. angew. Chem.* 1912, *25*, 1326) is of the opinion that the usual explanation of the process is wrong. His experiments seem to show that the fat is first emulsified by that part of the reagent which is insoluble in sodium chloride solution as a preliminary phase, and that in a second stage hydrolysis is brought about by the sulphuric and aromatic sulphonic acids. This hydrolysis has been studied by Grün and Corelli (*ibid.*, 665), and it seems that when triglycerides are acted upon by sulphuric acid, only diglycerides, probably in the form of sulphuric "acid" esters, result, together with the free fatty acid, and that monoglycerides do not appear, or at least cannot be isolated. The formation of diglycerides when triglycerides break down is also shown by the experiments of Madinaveitia (*Anal. Fis. Quin.*, 1912, *10*, 153) with acetic anhydride on tristearin, aceto-distearin resulting.

On former occasions we have drawn attention to the action of castor seed lipase. It has recently been shown that when a small electric current is passed through an aqueous suspension of the enzyme for a period of two weeks, a substance is produced at the anode possessing the power of hydrolysing methyl acetate, the solution at the cathode being inactive. A curious phenomenon has also been noted by Somerville (*Bio-Chem. Journ.*, 1912, *6*, 203), viz., that whereas aqueous emulsions of the castor bean rapidly lose their hydrolytic power when heated to 60° C., yet the beans themselves may be heated at 100° C. for prolonged periods without injury to the lipase.

A very interesting observation has also been made by Collins (*Proc. Durham Phil. Soc.*, 1912, *4*, 99) in connection with the enzyme of linseed, which, as is well known, contains a cyanogenetic glucoside from which the enzyme is able to liberate hydrocyanic acid. The harmlessness of linseed cake is usually attributed to the heating it is subjected to before pressing, but this observer's experiments show that the acidity of the stomach is sufficient to arrest the activity of the enzyme, which in pure water rapidly liberates the acid. Any derangement, however, of the digestive function leading to a diminution of acid production in the stomach may be attended with disastrous results.

In connection with analytical work (*Analyst*, 1912, 183) Bolton and Revis have continued their investigation of the Reichert-Meissl-Polenske-Kirschner values for the resolution of coconut and palm kernel oil margarine mixtures. The value of the process seems to be confirmed, and a series of curves and tables have been constructed. With Richmond, equations have been worked out for these curves which allow of the easy calculation of the constituents in a mixture. It is particularly noteworthy that the Polenske value is scarcely affected even by the presence of 10% of butter fat, and the certainty of detection of this latter fat by the Kirschner process (even in quantities such as 1%) is of real assistance in many cases. It must not be forgotten that a standard process and apparatus is absolutely necessary.

The peculiar action of benzoyl peroxide (lucidol) on certain well-known colour tests for oils is rather disconcerting. Halphen's and Baudouin's tests may be very much affected, at least as regards *intensity* of reaction; while in certain cases of excessive bleaching a reaction for sesamé oil may be obtained when that oil is not actually present (Utz *Chem. Rev. Fett. u. Harz. Ind.*, 1912, *19*, 70). Serger's test with sodium molybdate also appears to be much weakened (*ibid.*, 128 *et seq.*).

A new method of estimating the oxygen absorption of oils has been devised by Wilson and Heaven (*J. Soc. Chem. Ind.*, 1912, *31*, 565), which seems very simple in character. Linseed oil and poppy seed oil give nearly identical results, and though apparently no mixtures have been tried, the test might prove useful in detecting poppy seed oil in olive oil.

The new Bulletin of the Imperial Institute contains analyses of a great number of oils from little known seeds, etc., particularly from West Africa, Hong Kong, and other districts. These examinations are of great utility, in that they provide some means of identification when new oils appear on the market, and should be more widely known among analysts.

A considerable number of figures for some solid vegetable fats and tallows are given by Sprinkmeyer and Diedrichs (*Zeits. Untersuch. Nahr. Genussm.*, 1912, *23*, 581—596). They have examined many samples and give lowest and highest values for such comparatively well-known fats as Mowrah butter (the product of *Bassia longifolia*), Shea butter, Borneo tallow, etc., as well as those for less familiar fats, including Tulcuna fat (obtained from *Carapa procera*), Malukang butter (from the seeds of *Polygala butyracea*), and others. It is possible that Tulcuna fat is identical with carap oil, also a product of a species of Carapa, a tree of tropical America and Africa; Djave butter (from the seeds of *Mimusops djave*, a plant closely allied to that yielding Shea butter) is given under the name of Adjab fat. The author shows Malukang butter to have a Reichert-Meissl value of 45·5, a figure unprecedented among vegetable fats.

Among new oils, fats and waxes, the *Ch. of Comm. J. Suppl.*, July, 1912, draws attention to the increasing use of Candelilla wax, derived from the Mexican plant *Euphorbia cerifera*. This fact is attributed to the lower price as compared with Carnauba wax, and to the establishment of four factories at Montery which ship the product to Hamburg and the United Kingdom. At the same time, it has been found possible to recover a wax resembling Carnauba wax from a waste product of the cane sugar industry, and it is stated that this manufacture is already established on a commercial scale in Java.

The above journal also records the discovery in the Sudan of a seed yielding an oil similar to sesamé. This seed, named "senat," is likely to be of commercial value, as it is very plentiful.

The preparation of saturated fatty acids from unsaturated acids has repeatedly been investigated, and Forkin (*J. Russ. Phys. Chem. Soc.*, 1912, *44*, 155; *abs. J. Soc. Chem. Ind.*, 1912, *31*, 345) has recently shown that the conversion can be brought about by the addition of hydrogen bromide followed by reduction with zinc dust and water under pressure.

We have already noticed the growing value of various hydrogenisation processes for the production of solid fats from liquid oils in the presence of different catalysts. The great strides that these processes have already made is illustrated by the fact that a large factory has been erected in Norway for the manufacture of margarine fats by a process of this nature.

SOME CONSIDERATIONS REGARDING LATEX FORMATION.

By CLAYTON BEADLE and HENRY P. STEVENS, M.A., Ph.D., F.I.C.

(*Continued from page* 372.)

THIS is probably the most important evidence that has been so far adduced in regard to the function of the latex system, that is, as a channel for the passage of food material in the early life of the plant. Presumably such a system introduced thus early with a certain function will continue to exercise this function to a greater or lesser degree during the later development of the plant, particularly if the latex system persists and is found in every part of the mature tree, leaves, twigs, the cortex of branch, trunk and root system. Presumably also, the function of latex as a food material will bear some relationship to its chemical composition, that is to say, to the proportion of food materials that it contains.

The data of value might have been obtained from an estimation of the sugars, salts and soluble nitrogenous constituents which were thrown away with the waste liquors from the coagulation tanks and crêpeing machines, as these are the essential latex constituents from the point of view of the reserve food or food conducting theory. The amount of this food has been described as insignificant, but is this really the case? From our own analyses we calculate the figure to be about 7 per cent. of the total dry solids or about 3 per cent. of the latex under normal conditions. This, of course, is for latex from secondary tissue. If we take latex from primary tissue we find a much larger percentage of food constituents. There is nearly three times the percentage of nitrogenous matter in the latex obtained from leaf petioles as from the cortex of the *Hevea*. Hence we may conclude that the function of the latex system in the economy of the tree is of greater importance in the primary than in the secondary tissue. In the latter it is possibly of quite minor importance and indeed may contain products which the plant requires to get rid of. We have contended that the latex descends the tree from the leaves to the cortex, and chemical analysis shows a change in the composition during its passage down the tree. The physical condition of the latex is also changed. The relatively large highly diffracting caoutchouc globules found in the latex from the cortex are only present to a small extent in the latex from the primary tissue of the leaf, the latter consisting for the most part of much smaller globules of an altogether different appearance, and the dry solids give a higher acetone extract, that is to say, a larger percentage of resinous or oxygen-containing substances and a smaller proportion of hydrocarbon. Eventually the caoutchouc is left behind in the dead tissue of the cortex cut off by the phellogen. There are therefore some reasons for regarding caoutchouc as a waste product, which view is perfectly compatible with that of the laticiferous system itself as a means for the conveyance of foodstuffs as originally pointed out by Scott in the case of the cotyledons of the germinating seed. An explanation, however, is still wanting of the function of the caoutchouc in the latex. Why should it be formed only to be gradually got rid of as a waste product in the bark or the dead leaves shed by the trees when wintering?

It is most important to bear in mind that we have to explain not only the function of the caoutchouc globules, but also of the resin, whether present as separate globules or in conjunction with the caoutchouc. On account of the great technical importance possessed by caoutchouc in comparison with resin, one is apt to lose sight of the fact that the latex globules from latex-yielding trees consist quite as commonly of resinous matter as of caoutchouc. It is not easy to collect data on this point. Few analyses of latex are published, except those of trees yielding a commercial rubber, but to judge from the very limited number of trees which yield a rubber of technical importance as compared with the brief references to the large number of latex-yielding trees which are commercially valueless, the conclusion may be drawn that resin is probably even a commoner constituent of latex than caoutchouc. Hence any theory advanced to explain the function of caoutchouc in the latex should also explain that of the resinous matter. Such a theory was put forward in the January issue of the *Tropical Agriculturist*. In the first place emphasis is laid on the inert nature of the caoutchouc and resinous matter. These inert constituents are always present in a very finely divided form as minute globules, and the chemico-physical functions of matter in this state appear to have been lost sight of. Dr. Hans Molisch, in his "Studien über Milchsaft," also refers to the possible surface action of the globules, but the idea is not developed further. The functions we have referred to are those which invariably accompany matter in a finely divided form, that is to say, the surface concentration or adsorption of soluble substances on the insoluble particles in suspension exerts an appreciable effect owing to the large surface exposed. Some of the substances contained in the latex must be adsorbed on the surface of the globules, which in this manner act as carriers for the soluble constituents. The amount adsorbed will depend on the surface exposed, which, again, will depend on the size of the globules. These, as shown, are much smaller in the case of latex from the primary tissue; we have estimated the diameter as only about one-third of that of the average caoutchouc globule in latex from the secondary tissue of the cortex, consequently there will be three times the surface and three times the amount of material adsorbed. The latex in the primary tissues is therefore not only richer in foodstuffs, but the caoutchouc (and resin) is more finely divided and therefore more effective in holding and carrying a part of these foodstuffs. The considerations applicable to caoutchouc apply also to resins, the globules of which would have a similar action, so that the theory applies to both. The amount of material adsorbed will depend on the amount available in solution. If the concentration be increased by dissolving more of the soluble materials, part only of these would remain in solution, amd the remainder would be adsorbed; or if part of the soluble materials were removed so as to reduce the concentration of the solution, this would be to some extent counterbalanced by part of the adsorbed substance being given up to the solution. The effect of the presence of the inert caoutchouc or resin globules is to increase the capacity of the latex for retaining its constituents. For the same concentration of these constituents the capacity of the latex for holding certain of them may be much greater than if the caoutchouc globules were not there. The most important function of the globules is probably, however, the maintenance of a balance in the concentration of certain of the dissolved constituents. That is to say, when the adsorbed materials are drawn upon and removed from solution, the whole of the reserve is not at once removed, but fresh material is derived from the reserve held in an adsorbed condition by the globules, so that a reserve is always maintained, and the smaller this reserve the less easily is it parted with.

To test these suggestions properly, systematic analyses of latex are required over a considerable period, which should include the wintering period, and the analyses must give particularly the percentage and nature of the soluble constituents. The data at present available are insufficient to enable us to judge which of the soluble constituents are adsorbed; the selective action of the caoutchouc globules may play an important part.

INSTITUTE OF CHEMISTRY LECTURE.

Mr. Edmund White, B.Sc., F.I.C., delivered a lecture on "Thorium and its Compounds" before the members and students of the Institute of Chemistry at Finsbury Technical College on Friday, November 1st, Professor Raphael Meldola, President, in the chair.

The lecturer gave a short account of thorium since its supposed discovery by Berzelius in 1817 in the mineral gadolinite. Berzelius afterwards found that the substance he had christened thorium from the name of the Scandinavian god "Thor" was not an element, but he used the name in 1828 for an element which he discovered in the mineral called thorite. Thorium occurs in a large number of minerals in Norway, which are, however, only found in small quantities, such as æschenite, euxenite, gadolinite, samarskite, xenotime, monazite, orangite and thorite. The monazite sand deposits in Brazil form the chief commercial source of thorium at the present day. Monazite is found in many parts of Brazil, but the chief supplies have been drawn from sand found on the seashore. This sand was first shipped to Europe as ballast, but now that its value is known it is only allowed to be shipped after payment of royalties and other charges. Monazite sand also occurs in North America, India, Australia, Nigeria, Straits Settlements and South Africa. The process of concentrating the crude sand deposits by means of running water, followed by magnetic treatment, was described and illustrated by lantern slides, the problem being to remove the monazite in as pure a condition as possible from the complex mixture of minerals constituting the crude deposit. Purified monazite should contain not less than 5% thorium oxide. The importance of thorium in the gas-lighting industry was referred to, and the world's requirements in gas-mantles was estimated at about 400 millions annually. The interesting mineral thorianite was referred to as an ideal mineral for the extraction of thorium, but not available in sufficient quantities to be of much commercial importance. The value of monazite depends upon the percentage of thorium oxide it contains. This proportion is determined by analysis, and the various processes of analysis were described. General methods employed in the extraction of thorium were also dealt with, attention being drawn to the difficulties which arise from the thorium being associated in monazite with ten to twelve times its weight of the cerite earths.

Delicate tests were given to detect the presence of possible impurities, such as cerium, lanthanum, didymium, phosphoric acid, iron, aluminium, calcium and magnesium.

NOTES OF MEETINGS, &c.

CHEMICAL SOCIETY.

December 5th and 19th, at 8.30 p.m. Ordinary Meetings.

SOCIETY OF PUBLIC ANALYSTS.

December 4th, at 8 p.m. Ordinary Meetings.

SOCIETY OF CHEMICAL INDUSTRY.

London Section:—The next meeting of this section will be held on December 2nd, 1912, when the following Papers will be read and discussed:—

(1) "Slate Bed Treatment of Sewage," by W. J. Dibdin.
(2) "The Action of Organic Acids in the Softening of Dried Hides," by J. Gordon Parker.
(3) "Apparatus for the Examination of Mine Air," by Dr. L. A. Levy.

SOCIETY OF ARTS.

December 4th, at 8 p.m., when the following Paper will be read:—

"The Manufacture of Sugar from Wood, and its Economic Importance," by A. Zimmermann.

December 11th, at 8 p.m., when the following Paper will be read:—

"Natural and Synthetic Rubber," by Dr. F. Mollwo Perkin.

ROYAL INSTITUTION.

The eighty-seventh Christmas Course of Juvenile Lectures, founded in 1826 by Michael Faraday, will be delivered this year by Professor Sir James Dewar, F.R.S., his title being "Christmas Lecture Epilogues." The Lectures will be illustrated, and the dates and subjects are as follows:—December 28th, 1912, *Alchemy;* December 31st, *Atoms;* January 2nd, 1913, *Light;* January 4th, *Clouds;* January 7th, *Meteorites;* January 9th, *Frozen Worlds.* The lecture hour is 3 o'clock.

THE INSTITUTION OF CIVIL ENGINEERS.

December 3rd, 10th and 17th, at 8 p.m. Ordinary Meetings.

THE INSTITUTION OF MECHANICAL ENGINEERS.

December 20th, at 8 p.m. General Meeting.

UNIVERSITIES AND COLLEGES.

THE CHEMICAL DEPARTMENT OF THE UNIVERSITY OF BRISTOL.

By JAMES W. McBAIN, M.A., Ph.D., and F. W. RIXON, M.Sc., Ph.D.

THE first session of University College, Bristol, opened on October 10th, 1876; and as Professors of Chemistry, E. A. Letts was followed by Sir William Ramsay, Sydney Young, Morris W. Travers and Francis Francis. The gift of £100,000 by the late Mr. Henry Overton Wills in 1908 brought to a head the long desired wish for a University, and a Charter was granted on May 24th, 1909.

In 1909 the Chair of Chemistry was endowed by Mr. A. D. Pass in memory of his late father, A. Capper Pass, and to this Professor F. Francis was appointed. The first session of the University commenced in October, 1909, when the necessity for new accommodation was rendered very apparent. The new building was therefore commenced at Christmas of that year, and it was completed and in use within nine months, the approximate cost having been about £35,000, including equipment. Over 200 working places were provided, but the accommodation is already none too great. The total floor space is over 23,000 sq. ft.

PROFESSOR FRANCIS FRANCIS, Ph.D., D.Sc., F.I.C.

The structure is of steel, concrete and stone, so designed that nearly all the internal walls may be altered or removed as may ultimately prove advisable. Owing to the system of construction another floor may be added when necessary also. Finally, provision has been made for extending the main wing. The building is situated in a commanding position on a hill near the heart of the city, just above the chief street, although at some distance from manufacturing districts. The architect was G. H. Oatley, of Messrs. Oatley and Lawrence, who worked in close co-operation with the staff of the chemical department; the builders were Cowlin and Sons, also of Bristol. Oregon pine, stained, was used throughout the building with great effect, and plentiful use was made of dark red tiles set upon cement.

The rooms are arranged as compactly as possible; this is facilitated by the fact that, owing to the system of construction, a great deal of the outside walls consist of window space. Thus the Professor's private room and laboratory is very centrally situated in the midst of the laboratories for advanced work and close to the lecture theatres. Supervision is aided through the introduction of a number of glass windows in the walls between various rooms at a height of 5 ft. from the floor. This same principle is adopted in the main laboratory, in which what are practically private experimental rooms are provided for.

The rooms, of which there are twenty-nine in the department, with their arrangement, can be seen readily from the following scheme :—

BASEMENT.

Metallurgy, including Balance Room, Motor-Generators, Air Pump and Liquid Air with Main Switch Boards.	Corridor.	Research room.
Battery Room.		Workshops.
Shop for sale of apparatus.		Research room.
Unpacking Room.		Main Stores [Lift].

GROUND FLOOR.

Physical Chemistry. Professor's Room. Organic Chemistry.
Preparation Room. Balance Room.
Lecture Theatre. Corridor. Lecturer on Physical Chemistry.
Photochemistry. Preparation Room.
Museum. Lecture Room.

FIRST FLOOR.

Main Laboratory.
Balance Room. Preparation Room.
Library. Corridor. Biochemistry.
Microscopy.
Lecturer's Room.

Mezzanine Floors:—Dark Room and Constant Temperature Room.

loaned to the student, who pays a small sum for the use of it. The set is checked at the beginning and end of each session, breakages being deducted from the student's deposit. A printed list of the apparatus supplied is given to each student, who then checks his own apparatus, has defects made good, and faulty stuff replaced. This list is kept by the laboratory assistant, who uses it for the final check. The same system is carried out in all the laboratories, the sets of apparatus supplied, however, being different.

The total accommodation of this laboratory is for 144 students, only half of this number working at any particular time. Wall benches are reserved for emergency uses, and are not fitted for or apportioned to the students.

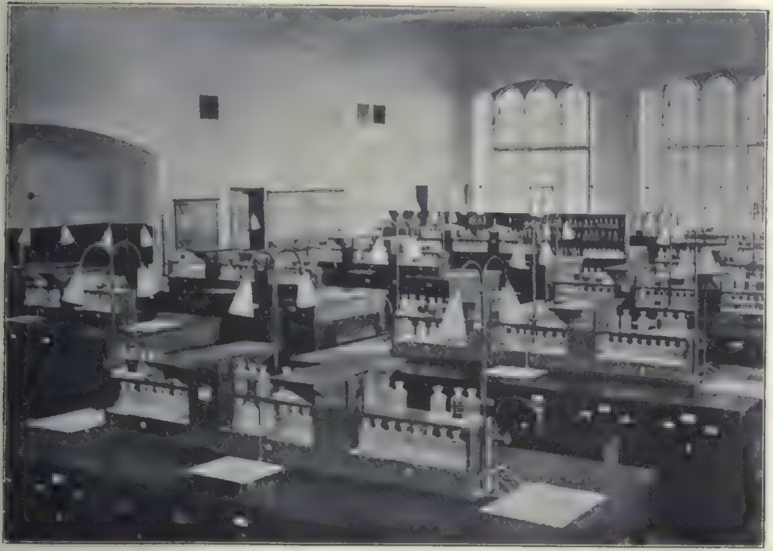
MAIN CHEMICAL LABORATORY.

Students spend the first two years in the main laboratory, taking their intermediate and first year final practical work in that room. Situated on the first floor, it is a lofty, spacious room, some 90 ft. long and 48 ft. wide. In addition to the lighting from three sides, top lighting is provided, making the laboratory one of the best lit that we have seen. The ventilation is carried out by means of fans, the chief exhaust being through fume hoods, two of which are placed on each bench; an air change at the rate of six complete changes per hour is supposed to be thus attained, but, if anything, this figure is too modest. Each island bench is fitted with twelve separate lockers and corresponding drawers, so that for every bench this number of students have their own private apparatus, which takes the form of a set of material, the property of the university,

The island benches themselves are 12 ft. long, 5 ft. wide, and 3 ft. high; the bench top is kept entirely clear, gas being brought to nozzles on the slightly raised central division, which serves also as a draught flue and bottle shelf. Bottles are as few as possible—sand-blasted lettering on two sides. On each bench one high tap, for washing out burettes, etc., is provided. The sinks are of the anti-splash type—brought flush with the bench top, the flange of the sink having a slight draining slope.

The receptacles for solid waste take the form of gutters, of enamelled and painted iron, fastened to the ends of the bench, which are recessed slightly for this purpose; these have proved eminently satisfactory, are easily cleaned, prevent accumulation of rubbish, and keep the floors clean.

Gas and water taps have nozzles tapering and grooved, the narrow end being ¼ in. outside diameter. Distilled water is obtained from a combined still and oven set.

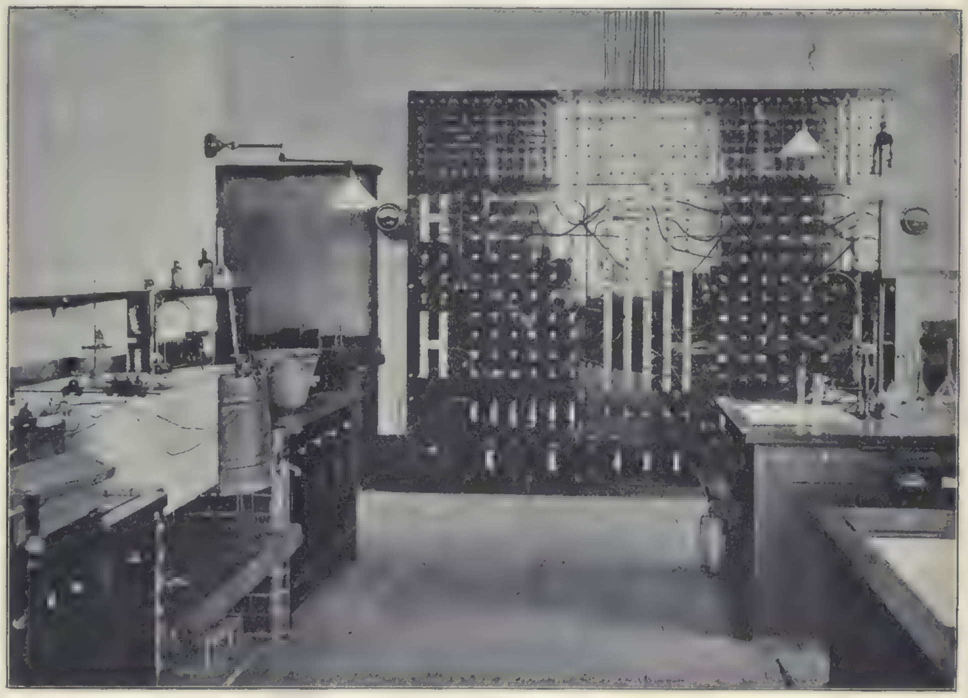


MAIN LABORATORY SHOWING BENCH FITTINGS.

An alcove in the room is set apart for blowpipe work; a lead-covered bench having attachments for ten blowpipes is used for the purpose. Compressed air is run to the table from a gasholder in the basement, which is charged by means of a small motor and fan. Some of the benches in the laboratory are arranged for electro-chemical work, being connected up with the department's five-wire system.

The fume chambers, another eminently satisfactory feature of the fittings, are large, have sashes hung, not on the usual sash-weight system, but on a single wire rope running over large pulleys to a counterweight hung on the wall. Side doors are fitted to the chambers whenever possible.

The bed of the chamber is of reinforced concrete covered with fine-grained, hard, red unglazed tiles; three open window benches in the room are treated in the same way. The tiles are not easily broken or cracked, stand well under furnaces, and would be easily replaced if broken.



THERMOSTAT BENCH IN THE MAIN PHYSICO-CHEMICAL LABORATORY.

As adjuncts to the main laboratory there are store-room and balance-room. The balance-room has a complement of fifteen balances, none but good balances (Sartorius short beam) are used, these even by intermediate students.

The stores form part of the general distributory system for apparatus. All goods are served from the basement main stores (records being on the card index system), and distributed by means of a lift to the subsidiary stores, one on each of the upper floors. All apparatus from store is loaned—purchase may be made from the shop if necessary. The shop and stores are kept entirely separate.

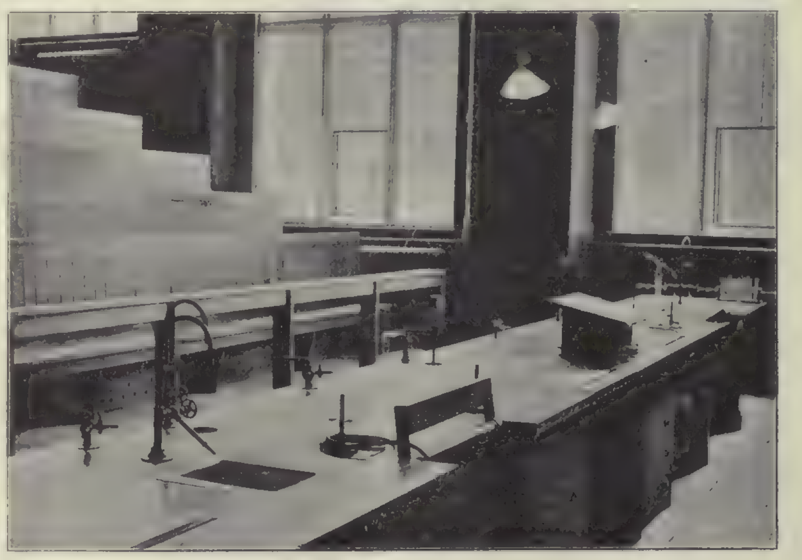
The details given above in connection with the main laboratory are carried out through the whole department. Further description of them will therefore be unnecessary.

There are two lecture theatres, the smaller accommodating forty students, the other seats 135. For popular lecture purposes this seating value may be doubled as ample room is allowed each student. At the back of the lecture table one finds a large sliding blackboard with a mechanism allowing of movement up and down by using one finger only, two fixed blackboards, diagram rack, lantern screen for a big Zeiss lantern used from the back of the room, and a smaller screen used for an experimental lantern on the lecture table, together with a through fume chamber in connection with the adjoining preparation room.

The lecture table, which is 24 ft. long and 3 ft.

wide, embodies certain successful novel features. Ample supply of gas, water and current, having all the controls at the back of the table, with hinged slotted flaps, enabling connections to be made readily, thus avoiding any tubes or wires on the edge of the bench. The switches are all 20-ampère indicator switches, one being provided for each terminal, and each of the eight distributing wires having binding screws at three points on the lecture table. Thus all connections can be finally adjusted before a lecture commences. A section of the table is in tile and concrete for furnace and combustion work.

The organic laboratory with twenty student places of the usual type has tiled hooded combustion benches with high water taps, long bench with free surface for large apparatus, fume chambers, a lead-covered bench for vacuum distillation having a slight slope towards a leaden pipe under which a basin may be placed to conserve any material in case of accident. An open-air bench on a verandah with glass roof *immediately adjoining* the laboratory proves exceedingly useful.



CHEMICAL LECTURE THEATRE.

Biochemistry has a separate laboratory of much the same size and arrangement as the organic laboratory.

In the metallurgical laboratory several island benches and long tiled wall benches hooded and connected to a special chimney serve for small furnace work. Wind furnaces and accommodation for larger electric furnaces are also provided. There is further a liquid air plant.

In the physico-chemical laboratory, which is of the same size as the organic laboratory, much more working space is provided by the use of long parallel benches 5 ft. apart, with a main passage 6 ft. wide at one end. It has been found amply sufficient and even convenient to reduce the passage between the tiled window benches and the other end to 18 ins. This has the further advantage that this gap may be bridged, thus allowing apparatus to be extended on to the window benches. The latter are on solid brackets supported only by the main wall. The laboratory is divided into two separate parts by a glass screen. In the smaller room the benches are 10 ft. apart, which permits of the use of moveable tables for special work; this system appears to us to be much more practical and economical than the recent tendency to reduce the permanent wall benches to mere ledges for supplying gas, water and current. The benches are 33 ins. high, the tops being almost entirely clear except for a single adjustable glass shelf capable of carrying 150 lbs. Each working place is provided permanently with 2, 4 and 6 volt current, and each is further adjacent to a special pair of terminals which may be supplied with any desired type of current. The fireproof thermostat benches, provided with gas, water and various types of current have proved exceedingly satisfactory.

Apart from the rooms described, some of the smaller laboratories (such as "Gas Analysis") are equipped essentially or exclusively for research.

The electrical equipment is elaborate, and it is quite unusually adaptable. The main storage battery consists of eighty-six accumulators, each of 300 ampère hours capacity. The cells are arranged mainly in groups of six, which can be further connected in any desired way, a few such groups being further subdivided. The groups are arranged in duplicate so that for special occasions the battery may be doubled, and, further, it is very rarely necessary to use cells which are being charged.

The main distribution board is in the physico-chemical laboratory immediately above the main switchboard and motor generators. This distributes the greater part of the current required in the university. The board contains no switches, but consists of fuses and terminals, each of which may be connected to any of the sources of current available on this board, namely, direct current of any voltage between 2 and 6 volts, alternating current at 105 volts, and special dynamo currents (the 500 volt current is distributed elsewhere). Current is thus distributed to sixty points in various departments of the University, including twelve points in the physico-chemical laboratory itself. The economy of this type of board may be seen from the fact that another sub-distribution board for sixteen points in another department cost £125, while this main board with its sixty points (including the currents supplied to that sub-switchboard) cost only £75. On the average, apart from the requirements in physical chemistry, it is found necessary to alter a connection on the distribution board only about once a month.

The terminal boards to which the currents are supplied on the working benches are very convenient, as they contain in addition to the binding posts a pair of pull-out fuses which serve admirably as switches.

The course for Honours B.Sc. requires four years after matriculation, that for the Pass degree three years. In the Science Faculty only three subjects (all science) are prescribed for each candidate. The first year is devoted mainly to quantitative work. Qualitative analysis occupies a large part of the second year, while the third year is devoted to physical and organic chemistry. The fourth year is essentially devoted to research work. Incidentally the students find it necessary to acquire a knowledge of German. Thus, Böttger's "Qualitative Analyse" is the only text we have used so far in qualitative analysis. Time permits only of a rather thorough qualitative analysis of mixtures of salts in proportion down to 1% of each; Kahlbaum's Chemicals "zur Analyse" are utilised in making such mixtures. Medical students are treated as intermediate students for their first year, and then carry out a special course in their second year.

The examination system offers unusual features in that the final examinations are in practice subordinate to the general standard of work throughout the course. Lectures to smaller classes are quite informal, and frequent occasion is taken to set a 15 minutes' written or oral examination (without previous intimation), the results being compiled and counting towards the recommendation for the degree. Similarly, a record is made of the results of all laboratory work and of the opinion of the lecturer upon it at the time. The result has been to raise the standard of work done and to reduce "cramming" to a minimum. With regard to the work entailed, a lecturer who is in real touch with his students would not have to do less, so that it is merely a matter of keeping the record permanently.

In view of the special facilities provided for research work, and with a view to encouraging interchange of students with universities in other parts of the world, graduates of approved universities are permitted to take the degree of M.Sc. after one or two years spent at research in Bristol, depending upon the nature of their degree. Bristol students are required to study for five years in the university after matriculation in order to obtain this degree; and the degree of D.Sc. is awarded after a minimum of two further years of work. Towards this degree the corresponding degrees of English and Foreign Universities (approved) are allowed to count in lieu of the Bristol M.Sc.

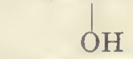
The research work throughout the University of Bristol receives considerable financial support from the University Colston Society.

THE DETERMINATION OF CHEMICAL CONSTITUTION.

By A. W. STEWART, D.Sc.

THE terms "chemical constitution" and "the determination of constitution" are expressions which occur very frequently in the literature of our subject, and it may be well to obtain some clear idea of what we mean by these phrases. Organic chemistry furnishes us with by far the greater number of examples, so we may confine ourselves to that field for the present. If we look back into the early history of the subject, we find investigators faced by a multitude of compounds whose properties at that time appeared to defy classification. Later, with fuller knowledge, it became possible to sort the various compounds into groups, each of which contained substances of a more or less similar character, such as alcohols or acids. Later, the general reactions of the various groups were classified; and at this point we find attempts being made to represent the reactions of substances by means of formulæ in such a way as to form a kind of shorthand chemical expression of the results of various reagents upon the bodies in question.

At this point two lines of thought diverge; and it is not without interest to find that each of the two authors of modern structural formulæ took an opposite side in the question. Kekulé (*Annalen der Chemie*, 1858, *106*, 149) regarded structural formulæ merely as records of the reactions which a compound had been made to undergo in the laboratory. On the other hand, Couper (*Phil. Mag.*, 1858, IV., *16*, 107) upheld the view that our structural formulæ might give us an actual insight into the linkings of the atoms within the molecule. At the present day, Kekulé's view has tacitly been dropped by most investigators, and the assumption is made that our structural formulæ do represent the ultimate constitution of the molecule as far as we can reach it by chemical means. Even in the simplest compounds, the limitations imposed by Kekulé are broken. For example, take the case of acetic acid, which we usually represent by the formula—



$$\begin{array}{l} CH_3—C:O \\ \qquad\ | \\ \qquad OH \end{array}$$

In favour of this formula we have the evidence of chlorination, which proves that the three methyl hydrogens are different from the hydroxyl one; we have proved the attachment of the remaining hydrogen atom to oxygen on the basis of the usual assumptions with regard to the action of phosphorus pentachloride. But when we come to the carbonyl group, we have no chemical evidence of any weight to prove its existence in the molecule, for it refuses to exhibit any of the reactions by means of which we usually characterise it. Thus the present-day formula of acetic acid rests partly upon reaction results and partly upon dogma; and it certainly cannot be truthfully described as a shorthand expression of the reactions of the substance, since one of the most characteristic groups in it refuses to manifest its presence in any of the usual ways.

We are thus driven to accept Couper's view of formulæ as a means of escaping from difficulties; and we assume that our structural formulæ really represent "the chemical constitution" of substances. But suppose that we take up the case of a tautomeric substance. Here we have a body which reacts in two different ways according to the reagents which we employ; and as a way out of the difficulty, Laar (*Ber. d. deut. chem. Ges.* 1885, *18*, 648) was driven to suggest that there might possibly be two or more structural formulæ for the same body. We have thus left the firm ground of *the* chemical constitution of compounds and have launched into a choice of formulæ according to circumstances.

The assumption now made with regard to such cases is that we have to do with an equilibrium mixture of two isomerides each of which is rapidly transformable into the other in presence of minute traces of certain reagents. Now if we introduce into the system any reagents which are capable of interacting with one isomeride, that body is removed from the system, the equilibrium is disturbed, more of the other isomer changes over in order to re-establish the equilibrium between the two isomerides, and finally we may get the whole of the second one transformed into the form in which the reagent can best attack it. Thus, unless we could devise some entirely neutral reagent which would attack both forms simultaneously and, at the same time, have no power of converting one form into the other, chemical methods are insufficient to give us the *exact* chemical constitution of the mixture of isomerides.

It thus becomes clear that in order to determine the constitution of compounds liable to isomeric change we must devise some method which involves no addition of reagents to the substances. Chemical methods having failed, we turn to physical ones to help us in the difficulty. The examination of the physical properties of a compound can be conducted on the pure compound itself or on its solution in an inactive solvent; so that if we can deduce the constitution of a body from its physical properties we have a method of constitution determination which is free from the drawbacks inherent in purely chemical methods.

But at this point we reach another difficulty. In order to determine the constitution of a compound by physical means such as refractive index or magnetic rotation, we must first draw up a series of constants (or something corresponding to them), each of which corresponds to a given atom or linkage within the molecule. For example, we have constants for carbonyl oxygen, hydroxyl oxygen, ethylenic bonds, etc. Now, each of these results depends upon results obtained by chemical means, so that we have got, not a really independent method, but rather a superstructure upon the chemical method. The consequence of this is that in those cases where the two methods disagree, as they not infrequently do, we must prefer the chemical method unless it is open to grave suspicion.

These incongruities between the results of the two methods, however, may conceivably lead us to most important results. We shall probably gain by taking a wider view of the whole question. On the one hand we have chemical evidence which tells us, as far as we rely upon it, that a given compound contains certain atoms which react in such ways as to convince us that they are probably attached to each other in a fixed order and that they occupy certain relative positions in three dimensions. On the other hand we have the evidence of physical properties which leads us to believe that certain groups within the molecule are not exerting their normal influence or may even show very little proof of their presence at all. For instance, the carbonyl radicle normally gives rise to a band at a fixed position in the absorption spectrum of substances containing it; but if we take a dicarbonyl radicle such as diacetyl, CH_3-CO-CO-CH_3, we get no trace of the true carbonyl band, but, instead, a new band makes its appearance in the spectrum; and conversely, if we examine the spectra of acetyl chloride, acetic acid or acetamide, we find no trace whatever of the carbonyl band.

Examples such as these suggest to us that possibly progress might be made if we were prepared to make a simple assumption. Let us imagine that we are dealing with a real substance which has a "constitution" which we may represent by C. Now when we examine this body chemically we deduce that it has a structure C_1 corresponding to its "chemical constitution"; and when we examine it by physical methods we get different results corresponding to, say, C_2. What we are doing at present is trying to find assumptions which will enable us to interpret C_2 in terms of C_1, while we entirely neglect the main problem, *i.e.*, the "constitution" C of the real substance. Instead of trying to force our physical data into the mould of our chemical ones, we should endeavour to trace both lines back to the original substance's properties, of which they represent merely two groups; and it is just those cases which at present seem to present the greatest difficulties which might help us furthest on the new path.

(*To be continued*).

CORRESPONDENCE.

The Editor will be pleased to publish letters dealing with subjects which may be of general interest.

Merck's Twenty-Fifth Annual Report.—This extraordinary useful collection of data connected with recent advances in pharmaceutical chemistry, covers 457 pages of subject-matter collected in a handy manner. It is pointed out that in 1887 the annual volume consisted of 15 pages. To-day it is printed in English, French, and Russian, in addition to the original German.

CURRENT LEGAL TOPICS.

By W. JAGO, F.I.C.

THE article of this series which appeared in the October number concluded with the remark that an appeal to legislation on the question of additions to food seemed to be in the air, and the suggestion was made that "it may be well for chemists to consider what should be their attitude on the general question." At the moment of writing, a question has been asked in the House of Commons by Mr. Bathurst as to whether the Local Government Board proposed to introduce this session a Pure Bread Bill. To this the President of the Board, Mr. John Burns, replied that, "A bill is in preparation. It will be general in character, and not confined to bread." There is therefore a very strong reason for such consideration by chemists as has been already suggested. In making the following comments, the present writer wishes to avoid anything which shall be regarded as dogmatising, and trusts that they may lead to expressions of opinion in this journal by those who can speak with authority on the various sides of the question.

There are two distinct schools of chemists whose professional duties lead them almost of necessity to approach this subject from different points of view. First, there may be taken those who are public analysts, whose function it is to aid in the local administration of the Food and Drugs Acts, and thus secure an efficient standard of purity in the food supplied commercially to the community. The very nature of their duties leads them to make this standard as high as possible, and in cases where zeal may possibly slightly outrun discretion, such standard may be too high, and thus an injury may be inflicted on the public. Some evidence of this is afforded by the attitude of certain public analysts toward the authorities of the Commissioners of Inland Revenue, colloquially known as "Somerset House." As is well known in disputed cases before the justices, a third part of the sample of an article which may be the subject of a prosecution is often referred to that body for analysis and report. Somerset House may therefore be regarded as an analytic Court of Appeal, and not infrequently its decision is adverse to the report of the local public analyst. Where such happens to be the case, instances have occurred in which the public analyst has declared the action of Somerset House to amount to a miscarriage of justice. The present writer feels it almost an impertinence to say that, so far as his experience goes, he has always found that Somerset House has held the scales of justice scrupulously evenly between the authorities who administer the Food and Drugs Act on the one hand and the purveyors of such food and drugs on the other. The more candid of the public analyst school of chemists will probably admit, that if they err at all, the exigencies of their profession will lead them to err on the side of maintaining too high a standard, rather than one which is too low.

Then there is, on the other side, those chemists who may be classed as manufacturing chemists. It is the business generally of the manufacturing chemist to improve to the utmost possible extent the quality of the manufactured article from any given raw material; and if the same quality is aimed at, his endeavours are directed toward making all possible improvements in the way of cheapening and bettering the processes of manufacture and securing the same results from cheaper raw material. A further object which he will naturally have in view is the maintenance of the same character and quality in the finished article, notwithstanding unavoidable differences in the character and quality of his raw material. Speaking generally, every one recognises the foregoing as being absolutely legitimate aims of the manufacturer and his chemical assistants and advisers. The natural aims of the food manufacturing chemist are the same as those which inspire the work of the general manufacturing chemist. If he can make a better article of food from the same raw material, or the same article from cheaper raw material, surely both these objects are equally praiseworthy. Further, if he can preserve uniformity in quality and character of his finished product, notwithstanding variations in his raw material, that also must be in itself a legitimate object. A question which at once arises is what limitations should be placed on him in effecting modifications in the directions indicated. Obviously, in the first place, he must not do anything which is injurious to the public health.

One of the very highest authorities as a public analyst has stated that "he was of opinion that the long-recognised and legitimate modes of manufacture should be adhered to, and the introduction of chemical meddling with food materials resisted. It should not be left to the discretion of the manufacturer of articles of food to say which constituents were valuable and essential, and which were not, and in no case should such removal be effected without due notice to the purchaser." This is a somewhat hard saying in the light of the steady improvement in foods generally, for which their manufacturers are responsible.

To take the article mentioned by Mr. Bathurst in his question, bread as a modification of wheat owes all its advantages to the manufacturer. Wheat itself is by no means well suited for human food when in its natural state. The first obvious step in its improvement was the grinding into flour or meal. Then next, this meal could be mixed with water and cooked. One of the earliest forms of cooking seems to have been the making of a thin dough or batter with flour and water and baking it on a hot plate, into a kind of biscuit or griddle-cake. The article thus obtained was probably the first known variety of bread. At the best it would be heavy and comparatively tasteless. The heaviness could be partly overcome by allowing the dough to stand for some time, when certain changes occurred by which gas was generated in its mass and the baked bread became much lighter and more porous in character. It was found that the addition of yeast as derived from the manufacture of beer and other analogous liquids produced a marked improvement in the same direction, and in fact transformed the heavy dough into the vesicular mass which when baked was a light and spongy loaf. Another modification was the addition of salt which from its flavour made the bread appetising and savory to the palate. This effect of salt is familiar to every one; but another property of salt not so generally known is that it exerts a binding or toughening action on the gluten of dough, and so causes that from a weak flour to make a bolder and more full-volumed loaf. Salt is in fact about the oldest bread-improver known, and if a baker has to work with a very weak flour one of his most familiar remedies consists in the addition of, say, an extra pound of salt to the sack. This employment of salt is therefore treatment with a foreign mineral substance, not as a condiment, but to remedy the defects of certain classes of flour. In both these cases the manufacturer has added foreign substances, yeast and salt, in order to improve the quality of bread as the cooked product of wheat. Were a "pure bread" bill to have been introduced before the use of yeast and salt had become common in bread-making, it is difficult to see how their employment would not have been prohibited and penalised. The logical result would have been that bread-manufacture would have remained in the griddle-cake stage, since the use of yeast and salt would be the introduction of chemical meddling with food materials.

Another familiar example of the evolution of a food product is that of whisky. In earlier days, whisky was obtained by distilling a fermented mash made from barley-malt used either alone or in conjunction with smaller quantities of indigenous raw grain. The distillation was effected in the very simple form of still, known as a pot-still. The selection of the raw material depended simply on that which was at the time the most available, while the pot-still was used not because it possessed any special virtues, but because it was the only kind of still then known. Subsequently, and especially for the London market, distillers commenced to substitute rice and maize for the indigenous Scotch and Irish grains, and conducted the operation of distillation in "patent" stills by which the separation due to return condensation was effected. The whisky thus produced was much milder in character, and more nearly approached pure alcohol in composition. The sale of this latter spirit as whisky gave rise to certain prosecutions in 1905, in which the magistrate decided that this spirit was not whisky. As a result, a Royal Commission was appointed to inquire into the whole subject. This Commission recommended that no restrictions be placed on the processes of manufacturing whisky, or on the grains that might be selected for its manufacture. The action of the distillers was thus justified.

Another interesting proposition for food-treatment is that of Budde of Copenhagen for the preservation of milk. The milk is first passed through a centrifugal machine, then placed in a vat and mixed with a small quantity of hydrogen peroxide. The temperature of the mixture is maintained at 50° C. for three hours, during which most of the peroxide is converted into water, and then a few drops of a catalase solution added in order to destroy any remaining trace of hydrogen peroxide. It is claimed that sterilisation is thus effected without the addition of any germicidal substance which permanently remains in the milk. The process is one of considerable interest and has commended itself to a large number of members of the medical profession; but evidently it is again a chemical meddling with an article of food.

As examples of chemical treatment in order to produce regularity, may be cited the addition of colouring matter to cheese and butter. The produce of some dairies is naturally paler than that of others, and in order to obtain a uniform colour, some annatto or other colouring is added in order to bring all the cheese or butter to a general standard. It may seem a matter of comparative unimportance whether one week's output of a butter factory is of the same or a different colour to that of another; but there are very few of those who are engaged in the sale of such articles but will know what an important factor this regularity in colour is in commercial value.

The bread-making and milk-treatment examples may be taken as illustrations of making a better article of food from the same raw material, while in the case of whisky a product equally well liked by some, and better by others, is made from cheaper materials. In butter colouring, uniformity of character is obtained. With regard to this latter, the suggestion is often made that the addition of colour is simply for the purpose of masking inferior quality. Doubts may, however, be raised as to this, since with a factory or dairy turning out a butter of regular quality and colour, any departure in the way of a fuller colour would be deprecated just as strongly as in the other direction. But in any case the question of whether an addition or modification of process merely hides, or whether it actually removes, a particular point of inferiority should be considered on its merits and decided accordingly.

It is agreed that every care should be taken to ensure the freedom of articles of food from anything which is injurious to the public health, and further, that if necessary, the law should be strengthened for that purpose. But it is also submitted that protection must be afforded to legitimate chemical developments of food-manufacturing processes. These have served in the past to improve the quality of such articles, and cheapen the cost of production, both of which are to the definite benefit of the public.

CHEMICAL ENGINEERING.

GAS PRODUCERS AND GAS-FIRED FURNACES.

By F. G. Fogg.

(*Continued from page* 388.)

An illustration of a very efficient reheating furnace for forging work, etc., is shown in Fig. 7. The furnace has double regeneration (air and gas) and temperatures suitable for welding and piling are obtainable.

Generally it may be said to be axiomatic that with gas firing an economy of about 30% in fuel consumption (apart from other incidental advantages) is certain of realisation over direct coal firing in furnaces whose ruling temperature is not less than 1,000° C.

In direct coal firing it is necessary, in order to obtain complete combustion, that an intense local heat should be maintained in the grate, and as some of the complex physical and chemical changes taking place during combustion absorb heat the temperature resulting from the simultaneous ignition of the combustible gases is appreciably lowered. In other words, gasification and combustion take place simultaneously in the hearth in the presence of an excessive amount of air, while with gas firing, the combustible gases are led from the producer direct to the furnace hearth where the heat is actually required. With direct coal firing it is found in practice that the theoretical amount of air for combustion must be very largely exceeded, while with gas firing the air is under exact control and owing to the intimate admixture of the air and gas, complete combustion may be obtained with almost the theoretical amount. Thus a higher flame temperature is obtained as less air (carrying a large volume of inert nitrogen which acts as a cooling agent and diluent) is admitted to the furnace, and the volume of the hot waste being proportionately reduced less heat is carried to waste up the chimney. It is to be noted also that a cheaper quality of fuel can be used in gas producers than is often necessary for direct coal firing.

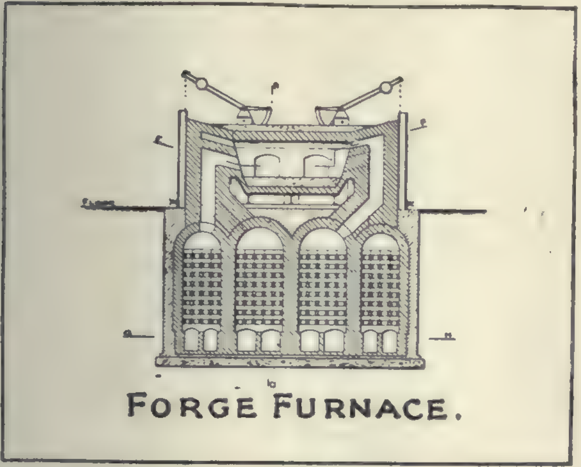


Fig. 7.—Forge Furnace.

In heating processes in which the products of combustion (waste gases) leave the furnace at a relatively low temperature, the economy in firing with producer gas is not so marked, for the reason that the heat losses inseparable from the gasification of the fuel in the producer, are not compensated for to the same extent by recuperation.

Notwithstanding the economies derived from gas firing there is still a very considerable amount of high temperature furnace work performed by direct coal firing, and it is curious that in this day of keen competition such operations as copper and tin smelting are not more generally performed by producer gas, though it is satisfactory to note that there is a gradual awakening now taking place towards the benefits of gas firing.

There is no difficulty in designing furnaces with special slag and dust pockets and other structural modifications to suit the peculiar properties of any metals, and it may be recorded that when applied on a comparatively small scale at a tin smelting works, a saving of 40% was made by gas firing in the weight of fuel used, and the output of the furnace was accelerated, at the same time, by 20%.

In addition to this the upkeep and repairs were very largely reduced, and the total saving was such that the cost of the change from direct firing to gas firing was recouped in about three years.

In the chemical industry gas firing finds many applications, but the furnaces used do not admit of any simple classification as they are usually specially designed to suit the particular properties, physical and chemical, of the material to be treated.

Recuperation is almost invariably effected by means of the parallel counter current principle.

In operations where direct flame contact with the material to be heated is permissible, and where cleanliness of the heating medium and a delicate control of temperature is essential, the advantages of gas firing are obvious, and the ease with which either a reducing or oxydising flame can be maintained render its use in many processes, most desirable, if not altogether imperative.

Roasting, calcining, drying and the concentration of liquors by evaporation are in many cases more economically effected by gas than by direct firing.

The process of briquetting is also much more economically effected by gas than by direct firing, and gas fired tunnel kilns are rapidly replacing coal fired systems, the consumption of fuel alone being reduced from about 20 to 9 tons per 100 tons of finished briquettes.

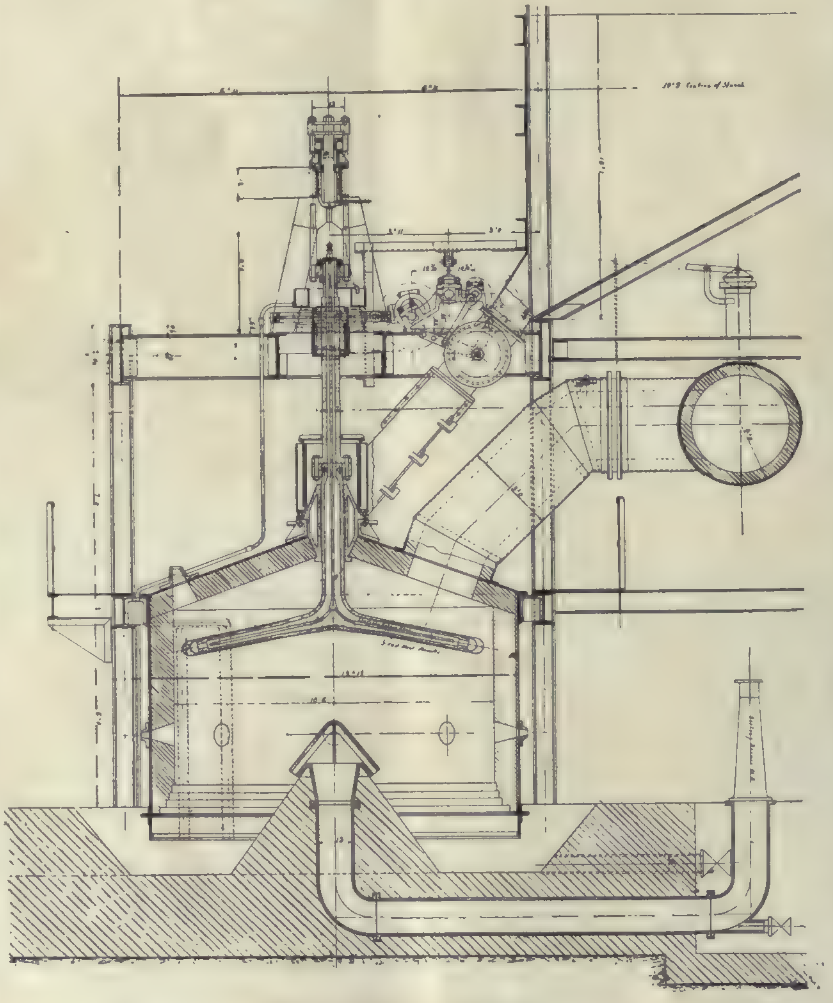


FIG. 8.—TALBOT PRODUCER.

In the glass industry producer gas has been used for many years, both for tank and pot melting, and here again the Siemen's type of furnace with double regeneration (air and gas) is almost invariably used. The consumption of fuel varies according to the quality of the glass, but it is good practice to melt one ton of tank glass with 16 to 18 cwts. of coal, a very considerable saving over direct coal firing, where it is usual to consume 1 ton of coal per ton of glass made.

The annealing ovens, with a continuous belt carrying the glass ware, also afford a very suitable operation for gas firing.

The brickmaking and ceramic industries still afford great scope for improvement in the more general adoption of gas firing, and large fuel economies are to-day being made in a number of modern gas fired kilns. In chamber kilns air recuperation only is required, and is effected by leading the air for combustion through the chamber containing the hot burnt material. By this means, temperatures between 1,600 and 1,700° C. are obtainable, and owing to the cleanliness of the flame and the uniform distribution of the heat the finest goods can be burnt direct (avoiding muffles), and wasters caused by local overheating in direct firing are practically eliminated.

Cool, clean producer gas (about 140 B.T.U. per cub. ft. net) from 7 to 8 tons of ordinary slack coal will burn 100 tons of high quality fire-brick, and so efficient are modern gas fired continuous kilns that with producer gas of only 120 B.T.U. per cub. ft. temperatures to melt Seger Cone 17 (1,470° C.) and over are obtained. Producer gas made from coke ballast (the finest screenings from coke oven batteries), until recently discarded as a waste product, is now used for burning fire-clay goods, 100 tons of finished material being made with a consumption of rather less than 12 tons of ballast.

Although the adoption of gas firing in place of direct coal firing invariably means reduced labour charges, very great interest is now being centred in the design of mechanically operated producers with the object of eliminating hand-labour as far as possible by combined mechanical feeding, poking, and ash removing.

A high thermal efficiency can only be obtained by absolute uniformity in operation, and, given a reasonably steady load, there is no doubt that a mechanically operated producer is the great desideratum, more especially in regard to large units. In this country mechanical producers are not, at the present time, used to any great extent, but a number of such plants in small units are in operation, and in some instances results have been sufficiently favourable to induce their duplication.

The Talbot Producer may be instanced as a type with mechanical feeding and poking (Fig. 8).

The producer is provided with a central blast and double mechanical feed, and ashes are removed through a water seal by hand-labour in the usual way. Originally the vertical shaft carrying the poking and levelling arm, which is water-cooled, was continued downwards to the foundation and carried in a footstep, but in later designs the poker is suspended from the top of the producer and no trouble is now experienced with burning as was the case whe the poker passed through the hot incandescent fuel zone.

The revolving poker is arranged to allow of a vertical adjustment of 12 ins. and the arm, which is more active as a leveller than a clinker breaker, can therefore be used to suit varying depths of fire.

The producer is not water-cooled, and it is usual to operate it at a rather high temperature and with a shallow fuel bed. Gas made in this producer has approximately, the following composition.

CO	26·5 %
H	10·0
CH_4	4·5
CO_2	3·2
N × H_2O	55·6
Total volume	100·0

Total combustible gases 41·0 %.
Calorific value (gas dry @ 0° C.).

B.T.U. per cub. ft. ..	gross	173
,, ,, ,, ..	nett	163

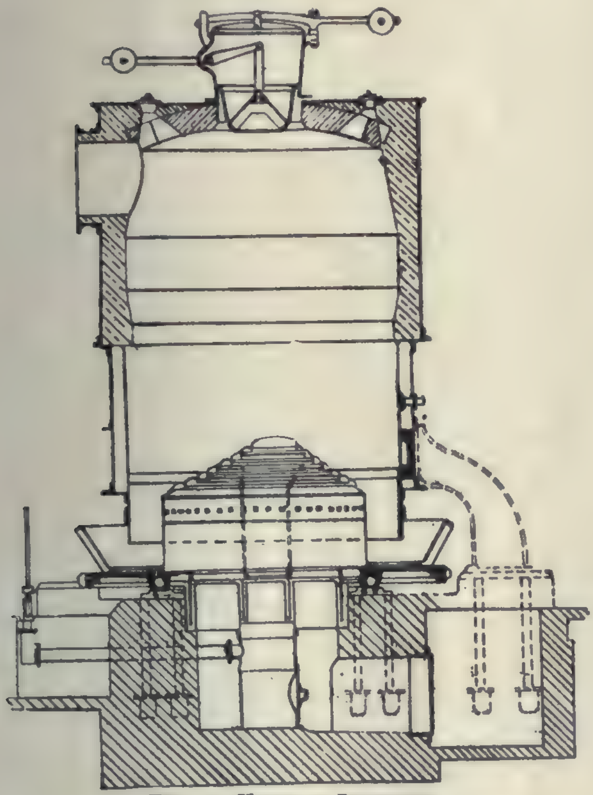


Fig. 9.—Kerpely Producer.

The mechanical removal of the ash is usually effected by means of a revolving hearth or table supporting the fuel bed and the Kerpely can be cited as one of the most largely used of such producers.

Referring to Fig. 9 it will be seen that the fuel is carried on a revolving grate to which is fixed a cone-shaped blast distributor with a rounded apex, through which there is an efficient central and lateral distribution of the blast to the fuel bed. The lower portion of the producer casing consists of a water-cooled jacket to prevent the adherence of clinker to the sides and thereby to facilitate the rotation of the grate, which can be speeded to any desired number of revolutions, according to the quality of the fuel and the rate of working desired.

The ashes in the rotating water trough impinge upon a fixed blade set at an angle to deflect them into small bogie wagons for disposal. The average quality of gas made from ordinary fuel in the Kerpely producer is given as follows, in volume per cent.

CO	27·2
H	9·7
CH_4	3·1
CO_2	3·8
N × H_2O	56·2
	100·0

Total combustible gases, 40 %
Calorific value (gas dry @ 0° C.)

B.T.U. per cub. ft. ..	gross	159·5
,, ,, ,, ..	nett	151·4

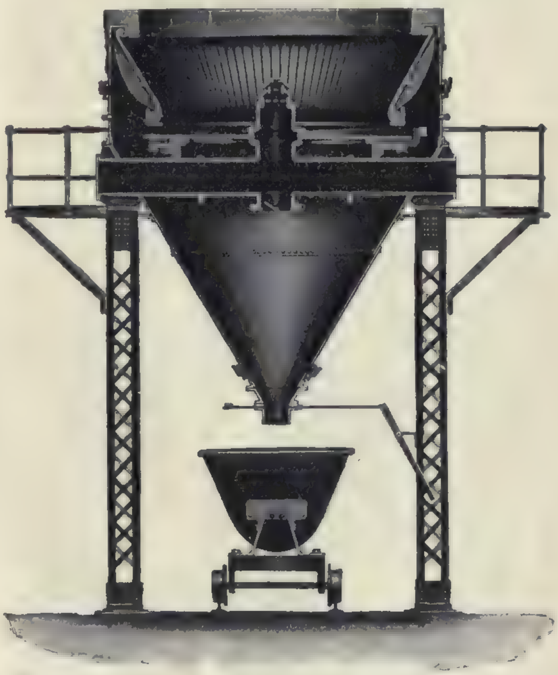


Fig. 10.—Mond Producer with Trump Mechanical Ash Discharge.

Fig. 10 shows the application of the Trump mechanical ash-removing grate to a Mond Ammonia Recovery Producer. In this case the producer is dry bottomed, and by means of a helical knife rotated slowly the ashes are continually pushed over the edge of the central table which carries the fuel bed into a steel hopper placed beneath, from which they are periodically removed, or, if desired, they can be continuously discharged through a revolving star drum on to a conveyor belt and deposited in an ash hopper. The producer combines the central and circumferential blasts and is very suitable for the gasification of inferior fuels high in ash.

Though it is perhaps early to pronounce upon the advantage of mechanical producers, it may be submitted that the scope of their successful application is limited to particular circumstances. To deal with fuels of abnormally high ash content the claims of mechanical ash removal would appear to be well-founded, but such inferior fuels are generally highly refractory under the process of gasification and it has been found that fuels amenable to easy treatment in producers with a circumferential grate (or combined central and circumferential grates) are unworkable with mechanical ash discharge. With some mechanical ash removing producers it is found necessary to use selected and often expensive fuels, and it would appear that such producers do not possess the elasticity of non-mechanical producers in dealing with fuels of varying qualities, while the gasification capacity shows no marked increase over the more extensively used producers with fixed grates.

In addition to the rather heavy first cost of mechanical producers the question of power for driving must be taken into account, and a still more important point is the cost of upkeep and repairs, regarding which it is still difficult to obtain precise and reliable information.

Keen controversy centres around the question of the suitability and economy of producer gas from which the ammonia has been recovered (Mond gas) for high temperature furnace work, involving the use of large quantities of fuel, and more particularly in connection with steel melting. There appeared in the July issue of this Journal, an interesting article on the commercial aspect of the Mond process in which it was pointed out that from ordinary slack coal containing the average amount of nitrogen (say from 1·3 % to 1·5 %) it is common practice to recover from 85 to 105 lbs. of sulphate of ammonia per ton of fuel gasified, or about 4 %, and that the cost of manufacturing the sulphate does not exceed £4 per ton, thus allowing a handsome profit with sulphate selling at £14 to £15 per ton.

Producer gas from recovery installations on the Mond system has a total heating value exceeding very considerably on the average that from many ordinary producer batteries. There is no variation in its composition, as recovery plants are worked automatically with scientific precision, but it differs from ordinary producer gas chiefly in that the carbon monoxide and hydrogen contents are, broadly speaking, reversed while the carbonic acid is very considerably increased as will be seen by comparing the following typical analysis of Mond recovery gas with the analysis of ordinary producer gas already scheduled.

CO	12·0
H	26·0
CH_4	3·0
CO_2	16·5
N × H_2O	42·5
	100·0

Total combustible gases, 41 %.
Calorific value (gas dry @ 0° C.).
B.T.U. per cub. ft. .. gross 162·6
,, ,, ,, .. nett 146·4

Though the more progressive steel makers have for the past ten years recovered in large quantities the ammonia as sulphate from the gas used in steel melting, forging, reheating, annealing and other high temperature furnaces, the bulk of opinion in the industry apparently remains sceptical and generally adverse to the use of gas with a high percentage of hydrogen—an essential feature of Mond gas.

It is established that when fired with recovery gas the output of material from a well designed double regenerating open hearth steel furnace is quite equal to that obtained when ordinary raw producer gas is used, while the repairs on the furnace are in no way increased. It is true that apart from the consideration of ammonia recovery the consumption of coal per ton of steel melted increases slightly as the producer blast becomes more highly saturated with steam, owing to the relatively larger quantity of hydrogen in the gas, and, consequently, of water vapour in the products of combustion which, on account of its high specific heat, increases the losses to the chimney, but with efficient and well balanced regenerating chambers this loss is reduced to a quantity almost negligible, and is in fact insignificant when the profits from sulphate are set against it.

It is remarkable that sulphate recovery gas plants are not more generally adopted and the valuable nitrogen constitutent of the fuel turned into a very profitable commodity instead of being utterly wasted.

Reference has already been made to the gasification on a large commercial scale of residual fuels which until very recent years were entirely discarded as waste products, and it has been noted that coke ballast—the finest screenings from coke oven batteries—is now used in specially designed producers with circumferential grates for high temperature fire-brick burning. When gasified under ordinary (non-recovery) conditions, such fuel, containing slightly over 20 % ash, will produce about 130,000 cub. ft. of gas (at 15° C.) with a calorific value of, approximately, 125 B.T.U. per cub. ft. nett, and no difficulty whatever is experienced in the working of the producer, the ashes being completely burnt. Coke ballast of similar composition derived from town gas retort screenings, and until recently wasted, is now used in independent producers to make gas for firing the retorts, thereby saving for market the larger grade of high quality coke previously used for this purpose.

As coke ballast contains, on an average, 1 % of nitrogen, it is eminently suitable for use in ammonia recovery producer plants, and in the Mond process yields about 120,000 cub. ft. of gas and 60 lbs. of sulphate of ammonia per ton gasified. The gas has the following composition :—

CO	9·0 %
H	22·0
CH_4	·8
CO_2	17·0
N × H_2O	51·2
	100·0

Total combustible gases, 31·8 %.
Calorific value (gas dry @ 0° C.).
B.T.U. per cub. ft. .. gross 115.

Several large producer installations using coke ballast are now working and others are in process of erection, and it is interesting to note that they are designed for the ultimate addition of ammonia recovery plant on the Mond system.

Colliery refuse—belt pickings and washery dust—containing about 40% ash, either alone or mixed with a small quantity of cheap low grade coal, is also amenable to treatment in specially designed gas producers, under either ordinary or ammonia recovery conditions.

Remarkable results in the way of high thermal efficiency by gas firing without recuperation have recently been achieved by a system of surface combustion developed by Professor Bone and Mr. C. D. McCourt (CHEM. WORLD, 1912, *1*, 198).

The advantages claimed for the process are: (*a*) the combustion is greatly accelerated by the incandescent surface and, if so desired, may be concentrated just where the heat is required; (*b*) combustion is perfect with a minimum excess of air; (*c*) the attainment of very high temperatures is possible without the aid of elaborate regenerating devices; (*d*) owing to the large amount of radiant energy developed, the transmission of the heat from the seat of combustion to the object to be heated is very rapid; (*e*) easy and perfect control of temperatures.

Industrially, the process has been applied in two principal forms; the diaphragm method, in which the gas and air in combining proportions are passed through a porous diaphragm of highly refractory material and caused to burn without flame at the surface of the exit thereof, which is thereby maintained in a state of high incandescence, and secondly, the incandescent granular bed method in which the mixture of gas and air is injected at a high speed into a bed of small irregular broken pieces of refractory material placed around or in the body to be heated.

The diaphragm method has been applied with great economy to such operations as evaporation or concentration of liquors, by means of the heat radiated from an incandescent diaphragm suspended over the liquid in a horizontal plane, while the second method is more applicable to furnace heating, steam raising, etc. By this method a temperature of 1,500° C. is obtained using clean producer gas (free from dust and tar) of 140 B.T.U. per cub. ft. nett, without any preheating of the gas or air supply, and by preheating the air supply by the escaping products of combustion, a heating effect has been obtained in a furnace with one-half the consumption of gas that would have been required from an ordinary flame gas fired furnace.

As applied to a specially designed tubular steam boiler on a large practical scale a thermal efficiency of over 90% has been obtained, and the system promises to open a new and important era in the more economical application of producer and other gases to the almost innumerable heating operations in the industrial world. Further developments in this direction will be watched with interest.

RECENT IMPROVEMENTS IN VACUUM EVAPORATION.[1]

By W. A. DAVIS, B.Sc., A.C.G.I.

ONE of the most important steps taken in recent years in improving methods of evaporation on the large scale has been the introduction of systems of evaporation *in vacuo*, either with simple or multiple *effet*. It is not the writer's intention to go into the question of the numerous types of evaporators that have been devised since the first introduction of the principle of vacuum evaporation in the sugar industry, in the form of the so-called "vacuum pans," but to describe some recent types of evaporating plant, with which he has had actual working experience and which, designed for certain specific purposes, present special characteristics not met with in most other types.

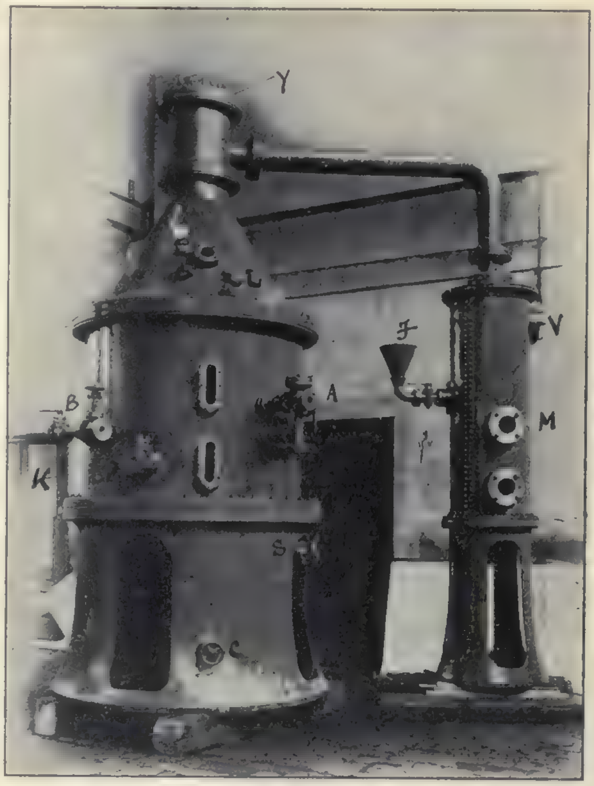


FIG. 1.—WEGELIN AND HÜBNER SINGLE-EFFECT EVAPORATOR.

It will be well, at the outset, to briefly point out the main reasons for the rapidly increasing use in work's practice of vacuum evaporation for concentrating liquors. These may be summarised as follows:—

(1) By evaporating under reduced pressure the temperature at which the ebullition of water takes place can be reduced from 100° C. (or above this in the case of concentrated solutions) to temperatures in the neighbourhood of 40° to 60° C., the exact temperature depending, of course, on the degree of vacuum maintained and the concentration of the

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[1] Reprinted from *The Central*, August, 1912.

solution undergoing evaporation. Pure water under a pressure of 50 mm. boils at 40° C., and with a well designed evaporator, in which a satisfactory vacuum is maintained by a good pump and condenser, it is possible to evaporate saline solutions (for example, those of potassium sulphate), which never become highly concentrated at saturation point, continuously at as low a temperature as 35° C. In the case of costly and easily decomposable organic materials, especially in the presence of mineral acids such as sulphuric acid, often present in such cases, the saving effected by concentration at such low temperatures, rendered possible by a vacuum, is often very great. At the same time cleaner and brighter liquors are finally obtained for crystallisation, free from deleterious products of decomposition, which deposit purer crystals, and in a shorter time than is possible when ordinary evaporation is adopted.

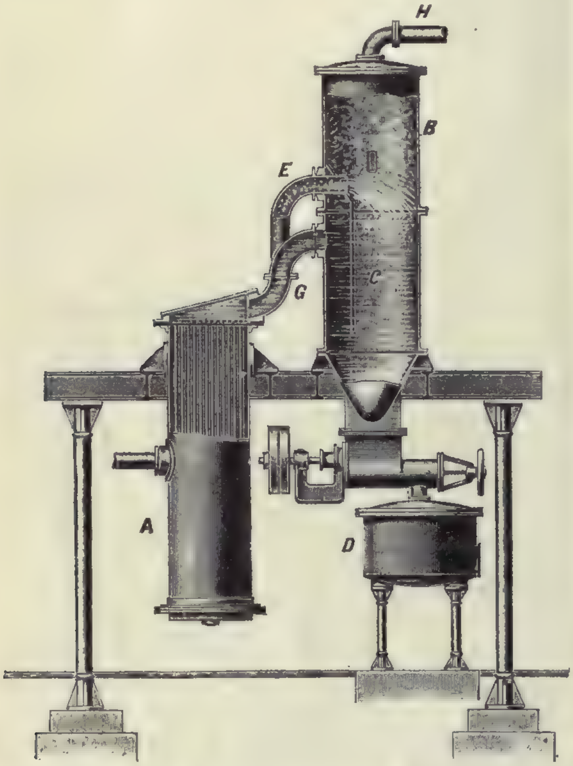

FIG. 2.—SAUERBREY RAPID EVAPORATOR : "SINGLE-EFFET."

(2) Evaporation itself is enormously accelerated. Charges which, for example, take 36 hours to evaporate with steam heating in the ordinary open pan, can be evaporated to the same degree of concentration in three hours, or even less in a " single effet " evaporator, whilst with a triple or multiple effet, when applicable, the rate of evaporation is still further enormously increased. The advantage of this increased rate of evaporation is felt in two ways in the work's economy; first, the output from the works in the same time can be very greatly increased; and secondly, the " solution " stock for the same output is enormously diminished. In many works, especially those manufacturing the more valuable chemicals, the solution stock held up in the evaporating vessels has a very great value, representing many thousands of pounds of idle capital. The difference made by the diminution of this solution stock alone by vacuum evaporation is often in itself more than sufficient to pay for the complete evaporation plant, without taking into account the other advantages accruing from vacuum evaporation, such as increased output, cleaner working, diminished destruction of material, and economy of fuel.

(3) *Economy of fuel.*—This of course is most pronounced in the case of the " multiple effet " evaporators, and although considerable even in the case of " single-effet "[2] is of itself in the latter case generally insufficient to justify the increased expenditure which a vacuum plant entails. A single-effet evaporator is generally used in cases in which it is essential that evaporation should be carried out with aqueous solutions, at a relatively low temperature, say 35° to 70° C., and in which at no time, even when the solutions become highly concentrated, must the temperature rise to anything like 100° C. In the double or triple effet, where direct steam is used to heat and evaporate the liquor in the first effet, and the steam from the first "effet" serves to evaporate the liquor in the second "effet," maintained under a suitable vacuum, the escaping steam from the second " effet " serving to heat the liquor in the third vessel, kept under a still higher vacuum, a certain drop of temperature necessarily occurs in passing from " effet " to " effet." Generally this is about 30° to 35° C. per " effet," so that if the first vessel is heated by direct steam at 110° C. the temperature in the second " effet " is about 75° C., and in the third " effet " 40° to 45° C.; corresponding vacua must of course be maintained in the different vessels. It is therefore often impossible to employ multiple evaporation in the case of organic compounds, which in solution must not be heated to a temperature approaching 100°, owing to danger of decomposition.

When, however, "multiple effet" evaporation can be utilised, as for instance in the case of solutions of mineral salts such as sulphate of potash, the economy of fuel is very great. With multiple evaporation a fuel which under ordinary conditions would evaporate, say, 4 lbs. of water per lb. of fuel can be made to evaporate 15 lbs. or more. The rate of evaporation is, too, enormously increased, and quantities of water as great as 50 tons per 24 hours are often evaporated in a single plant of moderate size.

One of the greatest troubles experienced in vacuum evaporators is the scaling of the heating tubes, owing to the deposition of insoluble salts, such as calcium sulphate. Such deposits rapidly diminish the heating effect of the steam and interfere with the circulation of the liquor; they not only cause waste of fuel and slower evaporation, but have the serious disadvantage of necessitating frequent and often costly cleaning. Many acid liquors pass to the evaporators nearly saturated with calcium sulphate, which is rapidly deposited on the heating tubes as the liquors are evaporated. In other cases, as, for example, the solutions of potash salts of the Stassfurt district, the solutions become saturated with calcium sulphate as evaporation proceeds, and, unless special precautions are taken, cause grave trouble.

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[2] This economy is due largely to the diminished loss of heat by radiation and air cooling, in the much diminished time of evaporation, the body of liquid being evaporated in a thick closed vessel, the temperature of which is not greatly above that of the surrounding air.

In the present article two different types of evaporator are described of special design to minimise the troubles caused by scaling. The first, shown in Fig. 1, is a "single-effet" evaporator, constructed by Messrs. Wegelin and Hübner, of Halle a. Sa., of hard lead (lead-antimony alloy), suitable for the evaporation of acid solutions. The evaporation is carried out in the left-hand vessel, the heating being effected by two heating coils wound spirally within the heating vessel, and supplied with steam by the double steam-cock A. Each coil can be used alone or both coils at once, the amount of steam admitted being regulated by screw cocks on A. In the hard lead evaporator shown, the heating tubes are of copper, "homogeneously" leaded on the surface to resist corrosion by acid. The liquid to be evaporated is sucked in at cock K, whilst the double cock B serves to admit steam for purposes of breaking "froth," or regulating the evaporation, or to admit water for diluting the liquor, or for washing out the evaporator. The cock S is of special design, and allows a sample to be withdrawn from the evaporating liquor without breaking the vacuum; L is a ball-valve, by raising which air is admitted so as to break or reduce the vacuum at any moment, as, for instance, if frothing occurs. The various glass windows shown enable the evaporation to be watched during its whole course, and accurately controlled. C is a screw wheel, by which the valve allowing the charge to be run out at the end of the evaporation, is operated.

The heating steam, by which evaporation is effected, passes through the heating coils, and the condensed steam is led away through suitable steam traps (not shown in the figure). The vessel M on the right-hand side, is an acid trap, by means of which any acid spray passing over is intercepted by milk of lime placed in M, and renewed from time to time through F; this lime can be drawn off by a pipe below M, not visible in the photo.

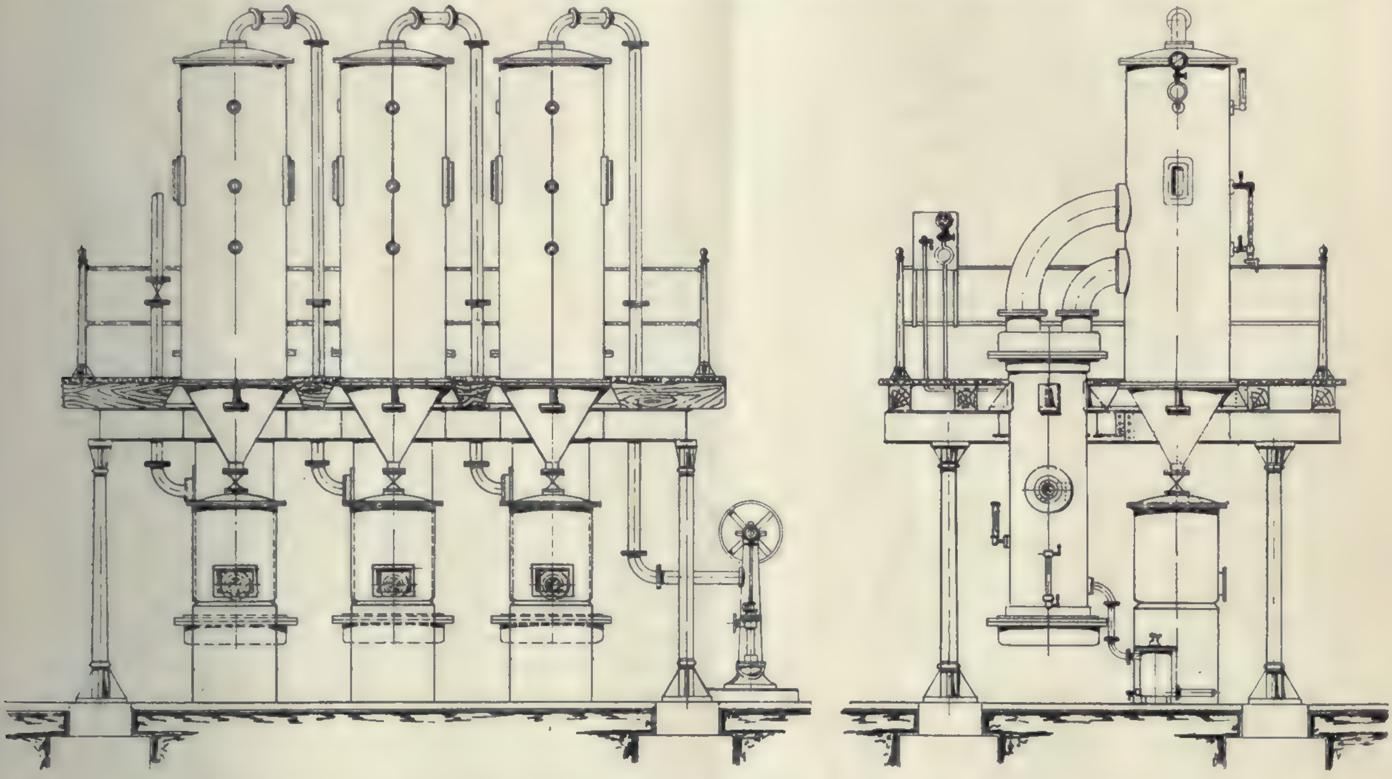

FIG. 3.—SAUERBREY RAPID EVAPORATOR: "TRIPLE EFFET."

Flange V is connected with the vacuum pipe, which passes first to the condenser, in which the evaporated steam is condensed; the condenser is in turn connected with the vacuum pump, which maintains the vacuum throughout the whole system. The condenser may be of the counter-current cataract principle, or, better, in the case when valuable products are being dealt with, of the tubular type, in which the condensing water passes through tubes round which the steam to be condensed circulates. In the latter case the condensing water does not mix with the condensed steam, which can separately be collected, tested, and, if necessary, dealt with to recover valuable material mechanically carried over.

Two, three, or four of these evaporators can be run in conjunction with a single condenser and vacuum pump by means of a suitable arrangement of pipes and valves.

The special advantage of this type of evaporator is found in the fact that even should scaling of the heating tubes occur, circulation of the liquids is not interfered with. Scaling itself occurs far less rapidly than in most types of vacuum evaporators, the greater part of the calcium sulphate, owing to the rapid swirl of the liquor during evaporation, produced by the conical distribution of the heating coils, is thrown down as sediment, without adhering to the heating coils themselves. When cleaning is necessary the evaporator can be rapidly cooled by admitting a small quantity of cold washing water, and allowing this to evaporate with the vacuum full on. The manhole Y, at the top, is then opened, and a man can enter to remove the scale mechanically. This is usually effected with very little difficulty, as the scale breaks away in lengths from the *outside* of the heating coil once it is started at any point by means of a chisel.

One other advantage of this type of evaporator deserves mention, namely, the rapidity with which the liquid to be evaporated can be brought into steady ebullition. In the case of frothing liquors, it is often difficult to get the liquid to boil steadily in the beginning, the whole mass of liquor tending to rise in the form of a thick foam. In the evaporator described, as soon as the liquid comes to the boil, the conical arrangement of the heating coil sets up a peculiar circular swirl, which is taken up by the sides and conical top, so that the liquor "turns over" and boils steadily in a remarkably short time.

In the Sauerbrey Rapid Evaporator (D.R.P. 207,309, English Patent, 1908, 501), the next modern type of evaporator to be considered, the same effect is obtained by a different principle. This type is of special service in the case of frothing liquors (such as Molasses "Schlempe"), which present difficulties with other types of evaporator. It is the outcome of many years' experience in the evaporation of the Stassfurt liquors containing potash and magnesium salts, and is manufactured by the Sauerbrey Maschinenfabrik, of Stassfurt. Its construction is shown diagrammatically in Fig. 2, which represents a "single-effet." The heating and evaporation are done in separate vessels. In A the heating vessel or "*Heizkörper*," steam passes around the tubes through which the liquid to be evaporated circulates; rapid circulation is brought about by this liquor being under the pressure of the liquid in B (the true evaporator), so that when one ebullition has begun the hot liquor from A is sprayed continuously in the form of jet E into the vacuous space of the evaporating body B. Many advantages accrue from this arrangement :—

(1) Frothing in B is prevented; froth, if formed momentarily, is broken up by the jet of liquid discharging into B.

(2) A greatly increased surface of evaporation is obtained by the jet being broken up into fine spray.

(3) As evaporation takes place in B the crystalline salt (for example, potassium sulphate) separates continuously, and can be continuously withdrawn by the mechanical device indicated at the bottom of the figure. The advantage of carrying out the heating and evaporation in separate vessels A and B respectively, is obvious; as all the evaporation is carried out in B no salt separates in A to clog the heating coils, and troubles with scaling are reduced to a minimum.

(4) Relatively large crystals are obtained by this system of evaporation, as the small crystals separating at the surface of the liquor sink but slowly through the mass of saturated liquor, and have a chance to grow. The result is that well formed or gritty crystals free from "mud," are drawn off at the bottom by the continuously acting "salt separator." The liquor freed from crystals by the separating partition shown, passes back automatically to the heating vessel, whence it is rapidly circulated again to the evaporator.

In Fig. 3 is shown the general arrangement of a triple effet Sauerbrey Rapid Circulation Evaporator, with automatic salt separators. The first heating vessel is heated by direct steam from the boiler, but the second heating body receives the steam from the evaporating vessel of the first "effet." The steam from the second "effet" serves in turn to heat the heating vessel of the third "effet," in which a high vacuum is maintained by a suitable pump. The vacuum in the third evaporator is maintained so that the boiling takes place at about 35° to 40° C., whilst in the second effet it causes ebullition at 65° to 70°. The first "effet" is at a temperature of about 100°. The condensing arrangement, generally a 30 foot drop-tube into which cold water sprays, so as to meet the evaporating steam from the third "effet," and in a cascade arrangement (not shown in the drawing), comes between the last effet and the vacuum pump. The side elevation shows the arrangement of the heating vessel and evaporating body. Generally two heating vessels are provided for each evaporating body, for continuous working, so that one heating vessel can be cleaned without interrupting the working. Pipes and valves are also arranged so that the liquor as it evaporates passes continuously from the first evaporator to the second and third evaporating vessels, in which the evaporation is completed. This type of evaporator lends itself particularly well to the concentration of heavy syrups, such as those obtained in the sugar industry, calcium nitrate liquors, caustic soda, etc.

The Absorption of Gases in Vacuum Tubes.—Mr. S. E. Hill recently gave the results of some interesting experiments before the Physical Society. In order to eliminate all electrode complications, the electrodeless discharge was used throughout. The bulbs examined were of soda, lead, Bohemia and Jena glass. The absorptions were noted at different pressures and curves plotted. Continued passage of a discharge causes a "saturation" effect in all the glasses. After two months none of the bulbs had recovered their absorptive power. If the action is chemical it is natural to expect various oxidation products to be formed. This was found to be the case, the first reading for the soda glass giving 95% absorption of hydrogen.

THE PHYSICS AND CHEMISTRY OF COLLOIDS.

By EMIL HATSCHEK.

CHAPTER IX. (*continued*).

THE general importance of adsorption hardly needs insisting on. Its connection with, and special importance in the study of colloids is also obvious; since all the systems dealt with under this head possess very large surfaces, adsorption is an essential, if sometimes very obscure factor of the whole complex of phenomena to be observed. Thus adsorption undoubtedly takes place, not only in gels, but also on the surface of the disperse phase in sols. This has been proved directly, by means of conductivity measurements, by Wolfgang Ostwald, and by several other observers. Many authorities even hold that the electric charge on the particles is due to absorbed ions, and that the coagulation by electrolytes belongs to the same category, viz., is an adsorption phenomenon. Without going into the details of what are still highly controversial questions, reference to them is necessary to remind the student that adsorption is likely to play an important, if not the determining, part in the formation and transformations of all disperse systems.

CHAPTER X.

IN the preceding chapters the reader has been furnished with a description—necessarily brief, but not omitting any feature of general importance—of the principal properties of disperse systems. It now becomes desirable to examine this whole mass of material with a view to finding, if possible, some general factors connecting the very various and striking phenomena.

We have been led to distinguish between systems in which the disperse phase consists of solid, or, more correctly, undeformable particles, and those in which the disperse as well as the continuous phase are liquid, that is, the disperse particles are deformable. In examining the former, we have found that there is a steady transition from suspensions to "suspensoids," due to the decreasing size of the particles and the consequent low velocity of settlement, increasing Brownian movement and increasing importance of the electric factors, which latter follows from the great increase of specific surface. The influence of the electric charge, although obscure both in its origin and its effect, on the stability of these systems has also received discussion.

In considering systems of two liquid phases, we have found that their chief mechanical difference from suspensions lies in the possibility of deformation, which makes it possible to have any phase ratio. We found that this phase ratio, or rather a large volume of disperse phase with a small volume of continuous phase, is essential for the manifestation of high viscosity. These points refer both to emulsions and to emulsoids, but a further peculiarity of the latter now deserves insisting on: the ready displacement of solvent from one phase into the other. We know that the disperse phase of the emulsoids consists of some form of aggregates containing large amounts of the solvent, and the striking changes in viscosity, and the sol-gel transformations under the influence of temperature, dissolved substances, etc., become referable to such a displacement of the solvent from one phase into the other.

In the emulsoid gels, such as silicic acid, gelatine and agar gel, we have finally become familiar with systems in which the continuous phase is solid—or, again to avoid certain difficulties—less deformable, and forms a skeleton or network filled with liquid. In these systems again the effect of surface becomes very marked, as some of their most characteristic elastic and optical properties are due to it.

We have finally studied in some detail the important phenomenon of adsorption or increased concentration on boundary surfaces. We have found that this occurs inevitably in all systems with large surfaces, and that it depends on two forms of energy inseparable from such surfaces, namely, electric and surface energy. Either of these factors may preponderate, or both may be active, in which case the phenomena become necessarily complicated, as in the case of dissociated substances.

It now remains to devote a few words to applications of colloidal science, both theoretical and practical. As regards the former, it can boast of one brilliant success: the study of the Brownian movement by Svedberg, Einstein, v. Smoluchowski and Perrin, which has afforded the most striking and convincing demonstration of the real existence of molecules. Less dazzling, but full of promise, are the numerous physiological investigations based on the properties of colloids which gradually tend to elucidate how many fundamental phenomena, such as muscle contraction, become explicable as processes of water displacement due to alterations in the reaction of the tissue. The study of adsorption compounds is beginning to clear up a great number of debated questions in many different fields, such as the properties of arable soils at one end of the scale, and—what is one of the oldest and most famous debatable points in that branch of science—the nature of the latent image in the sensitive film of the photographic plate, at the other.

As regards the practical applications, it may perhaps be well to remind the reader, on one hand, of the youth of the whole discipline discussed here, and, on the other, of the twofold way in which the development of a new branch of science may bear on industries and arts. It may, of course, lead directly to new processes and manufactures · an instance, is the production of squirted filaments of the refractory metals for incandescent lamps, which were made from the extremely finely divided metal coagulated from its sol. The much more general case—for which the growth of the chemical industries and of chemistry provides an illustration—is that it provides an explanation of phenomena long known and dealt with empirically. In this direction there is evidently a huge field for colloidal science, and the tilling—or at least the preliminary weeding and grubbing of the ground—may be said to be in vigorous progress. In all the industries which deal with organic raw materials, such as the textile and dyeing industries, brewing, tanning, the manufacture of explosive and other cellulose derivatives, to name only a few, there are numerous problems which have so far withstood solution by the methods of chemistry alone. For these the study of colloids provides, if not an answer at the first approach, at least an entirely new method of attack. It shows us that the mere subdivision of matter, or, in other words, the production of large surfaces, brings into play energies, the effects of which may be of the most varied character, and of the most profound importance. It teaches, further, that these effects may again be modified extraordinarily by small alterations in the reaction of the medium, alterations which have no purely chemical explanation. It has familiarised us with the idea of adsorption compounds, *i.e.*, combinations in any ratio, but perfectly definite in certain circumstances of temperature and concentrations. It is, of course, for the investigator to apply all these considerations to his own problems, but he may be assured that there still is much room for them and him—not only, as the familiar phrase, which is meant to stimulate, but succeeds in depressing, has it "at the top," but even at the bottom among the foundations.

PERSONAL AND OTHER NOTES.

Professor W. J. Pope was appointed Vice-President of the Cambridge Philosophical Society, at their annual meeting on October 28th.

Dr. H. H. Hodgson has been appointed Head of the Chemical Department of the Northern Polytechnic Institute, Holloway, London, N., in succession to Dr. W. H. Mills, who has been appointed Jacksonian Demonstrator at Cambridge.

The Council of King's College, London, has received from the Rev. Dr. A. C. Headlam the intimation of his intention to resign the office of Principal and Dean of the College at the end of the present year.

Mr. J. H. Darby of Sheffield has been awarded the Bessemer Gold Medal of the Iron and Steel Institute.

The Nobel prize for chemistry has been divided between Professor Grignard of Nancy University, and Professor Sabatier of Toulouse University.

The Royal Society have awarded a Royal Medal to Professor W. M. Hicks, F.R.S., of Sheffield University, for his researches in mathematical physics.

The Tenth International Congress of Agriculture will be held at Ghent, Belgium, in June, 1913.

At the recent Extraordinary General Meeting of the Members of the Institute of Chemistry, the recommendation of the Council, that the new building of the Institute should be erected at a corner site in Russell Square was unanimously confirmed by the Members. It is hoped that building operations may commence in next May. The Council hope to raise a further £4,000 towards the Building Fund.

The following have been recommended for election into the Council of the Royal Society for the year 1913, at the anniversary meeting of November 30th :—*President*, Sir Archibald Geikie, K.C.B. ; *Treasurer*, Sir Alfred B. Kempe ; *Secretaries*, Sir John Bradford, K.C.M.G., Professor A. Schuster ; *Foreign Secretary*, Dr. D. H. Scott ; *Other Members of the Council*, Lieut.-Col. A. W. Alcock, the Right Hon. A. J. Balfour, Sir William Crookes, O.M., Dr. F. W. Dyson, Professor W. Gowland, Sir Joseph Larmor, Professor E. W. MacBride, Mr. W. B. Hardy, Professor Micaiah J. M. Hill, Sir Ronald Ross, K.C.B., Professor G. Elliot Smith, Professor A. Smithells, Dr. J. J. Harris Teall, Professor Silvanus P. Thompson, Professor Sir J. J. Thomson, Sir Philip Watts, K.C.B.

Professor Blackman will deliver a course of about twenty lectures on "The Pathology of Plants," at the Imperial College of Science and Technology, beginning on January 14th, 1913, and every Tuesday and Friday following, at 11 a.m.

Nature reports that at the statutory meeting of the Royal Society of Edinburgh, held on October 28th, the office-bearers for the ensuing year were elected as follows :—*President :* Sir William Turner, K.C.B., F.R.S. ; *Vice-Presidents :* Dr. J. Horne, F.R.S., Sir Thomas R. Fraser, F.R.S., and Dr. B. N. Peach, F.R.S., Dr. J. Burgess, Professor T. Hudson Beare, Professor F. O. Bower, F.R.S ; *General Secretary ;* Dr. C. G. Knott ; *Secretaries to Ordinary Meetings :* Dr. R. Kidston, F.R.S., and Professor A. Robinson ; *Councillors :* Dr. R. H. Traquair, F.R.S., Professor J. Walker, F.R.S., Sir W. S. M'Cormick, Professor Crum Brown, F.R.S., Professor T. H. Bryce, Mr. W. A. Carter, Mr. A. Watt, Dr. J. H. Ashworth, Professor George A. Gibson, Professor R. A. Sampson, F.R.S., Professor D'Arcy W. Thompson, C.B., and Professor E. T. Whittaker F.R.S.

Steps are being taken for the endowment of a University College for Sussex, and three offers of £1,000 each, provided two other similar sums are forthcoming towards the scheme, have been made.

Sir Robert Pullar, LL.D., head of Messrs. J. Pullar & Sons, Ltd., of Perth (dyers), who died on September 9th last, left estate of the total value of £519,675, of which the personal estate in the United Kingdom amounts to £488,959.

Science reports that £20,000 has come to the University of California from the estate of Mrs. Carrie M. Jones of Los Angeles, to endow scholarships. Also from the same source it is announced that Mount Holoyoke's alumnæ committee reports that its efforts to raise £100,000 for the college have met with success.

REVIEWS OF BOOKS.

"AN INTRODUCTION TO BRITISH CLAYS, SHALES AND SANDS." By Alfred B. Searle. CHARLES GRIFFIN & Co., LTD., London, 1912. Pages 451 + xi., including 10 Plates and 35 Figures. Price 7/6 net.

The opening chapters contain an account of igneous and sedimentary rocks, the processes by which clays have been formed from them, and the position of various beds that are of importance to the clayworker. These are succeeded by one on "The Chief Characteristics of Clays and Shales," in which the different materials are arranged in alphabetical order. A brief description of "Materials similar to Clay" is followed by a chapter on the "Mineral and other Constituents of Clays," in which the non-argillaceous constituents are regarded as impurities. The chapter on "The Physical and Chemical Properties" includes a useful *résumé* of the different theories that have been advanced to account for the plasticity of clays, and a careful description of the changes produced on firing. The remaining chapters deal briefly with "Prospecting, Mining, and Quarrying," "The Purification and Preparation," and "The Legal Position of Clays," respectively.

The book contains much information, and bears unmistakable marks of great industry on the part of the author; but on laying it aside most readers will have a feeling of disappointment that so much time and labour have been expended on an undertaking which scarcely affords the assistance that might have been expected.

With regard to a new book of this description, two questions very naturally present themselves to the mind, namely, "For whom is the book intended?" and "How far is it calculated to meet the requirements of the class of readers for whom it is written?"

Regarded from these points of view, it is difficult to decide for whom large portions of the chapters on the geology of clays were meant. If they have been written to give those interested in the utilisation of clays an introduction to the study of geology, the ground covered is much the same as that of an elementary text-book, and if not for that purpose, the descriptions of the ordinary processes of denudation and sedimentation could certainly have been omitted. The descriptions are necessarily so directly concerned with the formation of clay strata, and interwoven with highly specialised and complicated points, such as kaolinisation, that a perusal of this portion of the book would scarcely furnish a reader, possessing a general acquaintance with physical geology, with a convenient method of revising his knowledge of the subject. The inclusion of a few sketch maps of the formations would have increased the usefulness of the sections dealing with the geographical distribution of clays, and would certainly have been of greater service than the elaborate illustration of a typical ammonite from the Speeton Clay, a formation of no importance to the practical clayworker. The frontispiece is an outline map of nearly the whole of the British Isles, on which "the chief clayworks" are represented by dots, though it is by no means clear whether these mark the pits from which the clays are won, or the works in which they are used. This map would have been very useful if the localities could have been identified.

The arrangement of the matter is not as concise as it might have been, and has given rise to much unnecessary repetition. For example, the clays of Ewloe and Buckley are described as specially suitable for the manufacture of acid-resisting ware on page 174 and on page 243. Again, MacAlister's suggestion that the fluorspar present in china-clay rock was formed by the interaction of fluoride vapours and the lime in the felspar is mentioned on page 10 and also on page 36, and Table XII. on page 283 re-appears as Table XV. on page 300. The title of Chapter VIII., "Mineral and other Constituents of Clays," is not wide enough to cover all the contents, which include quartzite, glass-making, and monazite sands, though the last would hardly be referred to as "British."

The book contains remarkably few references to original papers, so that it would be of no help to any reader who wished to pursue any particular subject further. One of the few references given (page 154) is incorrect, and should read Trans. Eng. Ceramic Soc.

The Index has been laboriously compiled, apparently with scarcely any omissions, but is very inconvenient as a means of reference, for in cases where a subject is mentioned on several pages, there is no means of recognising, for instance by the use of leaded type, on which the chief description is to be found. For example, a reader who wishes to obtain information on clays suitable for tile-making, finds references in the index to twenty different pages. The first merely refers to the geological position of certain tile-clays, namely those of the Shropshire Coal Measures; the next simply states that various lias clays are employed in the manufacture of bricks, tiles, and drain-pipes. Not until eleven references of a similar kind, some of which are only repetitions, have been waded through is the main description of "Roofing tile-clays found."

The book has certainly been brought well up to date, and contains very fair and impartial statements of several subjects which have attracted attention during recent years, such as the theories of the cause of plasticity, the colloidal character of clays, together with Ashley's experiments on the absorption of organic dyes, "surface factor," etc.

The reader is left to form his own conclusions, and the author has made no attempt to bias the judgment on the questions, nor scarcely to indicate his own views on the points at issue. The description given of many practical details in the manufacture of clay goods, while familiar to those engaged in the industry, should prove useful to many who have not had opportunities of following the processes in a works, but still wish to gain some knowledge of them.

The range of the book, so far as British clays are concerned, is much the same as that covered by Ries' book on Clays, in which special reference is made to those of the United States, and it is a matter of regret that the logical arrangement and clear style of the latter has not been followed more closely in the volume under review.

W. C. H.

Books Received.

"TRATTATO DI CHIMICA INORGANICA GENERALE E APPLICATA ALL'INDUSTRIA," by Ettore Molinari. Ulrico Hoepli, Milano, 1911. Pages 913 + viii, including Index. Divided into 3 Parts, including 280 Illustrations in the Text and 3 Plates. Price L. 16.

"THE PREPARATION OF ORGANIC COMPOUNDS," by E. de Barry Barnett. J. & A. Churchill. London, 1912. Pages 310 + vi, including Index Chapters XII., with 50 Illustrations. Price 8/6 net.

"FATTY FOODS; THEIR PRACTICAL EXAMINATION," by E. R. Bolton and Cecil Revis. J. & A. Churchill, London, 1913. Pages 371 + v, including 2 Indexes and 5 Appendices. Chapters IX., with 36 Figures and 6 Plates. Price 10/6 net.

"SECOND STAGE INORGANIC CHEMISTRY, THEORETICAL," by G. H. Bailey. Edited by W. Briggs. University Tutorial Press, Ltd., London, 1912. Pages 544 + vii, including Appendix and Index. Chapters XXXI., including 109 Illustrations, with Frontispiece. Price 4/6.

"MODERN INORGANIC CHEMISTRY," by J. W. Meller. Longmans, Green & Co., London, 1912. Pages 871 + vii, including Index. Chapters XLIII., with 316 Illustrations. Price 7/6.

"DYEING AND CLEANING." A Practical Handbook, by F. J. Farrell, Third Edition. Charles Griffin & Co., Ltd., London, 1912. Pages 253 + viii, including Appendices and Index. Chapters VII., with 81 Illustrations. Price 5/- net.

"THE EFFECT OF STEMMING ON THE EFFICIENCY OF EXPLOSIVES," by W. O. Snelling and C. Hall. Technical Paper 17, Bureau of Mines, Washington, U.S.A., 1912. Pages 20, including 11 Illustrations.

"MAGAZINES AND THAW HOUSES FOR EXPLOSIVES," by C. Hall and S. P. Howell. Technical Paper 18, Bureau of Mines, Washington, U.S.A., 1912. Pages 34, including 5 Illustrations, and 1 Plate.

"NOTES ON MINERAL WASTES," by Charles L. Parsons. Bulletin 47, Bureau of Mines, Washington, U.S.A., 1912. Pages 44.

"E. MERCK'S ANNUAL REPORT OF RECENT ADVANCES IN PHARMACEUTICAL CHEMISTRY AND THERAPEUTICS." Vol. XXV. E. Merck, Darmstadt, 1912. Pages 508 + vi, including 4 Indexes. Price 1/6.

COMMERCIAL AND GENERAL NOTES.

Sicilian Sulphur Production and Trade.

At the end of 1911 the "Consorzio Obbligatorio per l'Industria Solfifera Siciliana" looked back on the fifth year of its existence, during which time it has fulfilled its difficult task in a very satisfactory manner. Its main object was to prevent overproduction and the resulting accumulation of raw sulphur, as well as to open up new markets for the Sicilian produce. The production during the season 1910—1911 amounted to 391,978 tons compared with 396,737 tons in the previous year, 396,295 tons in 1908—1909 and 407,277 tons in 1907—1908.

The decreased production is partly accounted for by the exhaustion of old mines, and partly by the constantly increasing labour difficulties on account of the growing emigration. The number of sulphur mines has gradually fallen off, for there were only 476 in 1911 against 720 in the first year after the formation of the Consorzio.

Contrasting with the diminished production is the increase of the quantities sold. These amounted to 456,227 tons last year, compared with 161,318 tons five years before.

Some of the reasons for the increased export demand for Sicilian sulphur are the growing consumption for chemical purposes, the extension of the sulphite industry in Sweden, the lessened production of sulphur in Calabria and the substitution of the Sicilian product for Japanese sulphur by Australian consumers. It is said that the Consorzio has entered into an agreement with the Union Sulphur Company of New York to regulate values.

Growing Consumption of Fatty Vegetable Substances in the Danish Margarine Industry.

An interesting feature of the recent development of the margarine industry in Denmark is the increasing consumption of fatty vegetable substances which are taking the place of those of animal origin. The use of the latter has diminished in a remarkable degree during the last five years, for they represent now only 30% of the raw materials used, while 70% consist of vegetable substances. In 1908 the proportion was exactly the opposite one. This substitution has greatly stimulated the Danish oil-crushing industry, and considerable quantities of copra and sesame oils are pressed by the Danish mills.

Denmark is one of the largest producers of oleomargarine among the European countries. Her production in 1911 amounted to 78,043,630 lbs., representing the output of twenty-nine factories.

Alleged Prosecution of a German Chemical Firm by the French Government.

A French contemporary contains the astonishing news that the Government has instituted legal proceedings against the German chemical firm of "A.-G. für Chemische Industrie, vorm. H. Scheidemandel." This prosecution is said to have been prompted by the fear that the German concern intended to absorb the whole French agricultural-chemical industry and trade by consolidating a number of important French glue and fertiliser works and forming new firms. According to article 419 of the French "Code Pénal" any firms or individuals selling goods or provisions, amalgamating or uniting in order to control the values of these goods, or causing these to rise or fall "by fraudulent means," are liable to be imprisoned for at least one month up to a year, and to a fine of from 500—10,000 francs.

Cheap Alcohol for German Manufacturers of Artificial Silk.

THE German manufacturers of artificial silk have obtained a valuable concession from the "Berliner Spiritus-Zentrale" for the season 1912—1913. According to an arrangement the average price of industrial alcohol to the manufacturers of artificial silk will be about the same as that which their foreign competitors have to pay. This may enable the German makers of nitrocellulose artificial silk to compete more successfully with imported goods.

Almost from the beginning of the industry the makers of silk by the "nitro" process have been severely handicapped by the high prices of industrial alcohol, and their repeated efforts to obtain a reduction have been quite unsuccessful for nearly seven years. The intervention of the Government and a good potato crop in Germany helped to bring about the desired result which is the cause of much satisfaction in German manufacturing circles.

Uranium and its Uses.

There is considerable popular interest in uranium in the United States on account of its connection with radium, the properties of which appear so marvellous when compared with those of more familiar materials. Very little uranium is mined in the United States, except as it is incidentally taken out in mining carnotite for vanadium. In 1911 the uranium mined amounted to about 21·2 tons. A few hundred pounds of pitchblende was taken from the German mine, at Central City, Colorado, but this material was not sold, as it was used in experimental work.

The extraction of radium has been attempted in the United States by several persons; some of them have given up their efforts, but others are still at work, with what success is unknown. The uses of uranium and its compounds are comparatively few. It is employed principally for making yellow glass, for making yellow glazes for pottery, and in a less degree as a chemical reagent. Yellow glass made with uranium is known as "opalescent." Some of the firms who have attempted to use uranium in the manufacture of steel have abandoned such experiments, the claim being made that it imparts almost the same properties as tungsten and is very much more expensive.

Peroxide in Toilet Preparations.

In a paper read before the North-western branch of the American Pharmaceutical Association at Winona, Minn, J. S. Brewer made the following observations concerning the use of peroxide of hydrogen, or hydrogen dioxide, in cosmetics and other toilet preparations.

Peroxide has come into considerable prominence as an addition to greaseless creams which are marketed as peroxide creams. In making these creams the solution is usually employed, as the peroxide of various metals are rather coarsely powdered, and make the cream gritty. Peroxide creams are unsatisfactory because the peroxide rapidly decomposes after being combined with organic matter such as stearic acid. In addition to this most greaseless creams or peroxide creams are slightly alkaline, which neutralises the acidity of peroxide, causing its rapid decomposition.

Peroxides of the metals, such as calcium, magnesium, zinc, sodium and strontium, are much used in dental preparations. Their stability in dental pastes is questionable, but in powders they are of considerable value, only giving up their oxygen in the presence of moisture. These metallic peroxides are also employed with advantage in deodorising powders.

M. L.

BRITISH STANDARD SPECIFICATION FOR SOAP LYE AND SAPONIFICATION CRUDE GLYCERINE.

SOAP LYES CRUDE GLYCERINE.

Analysis to be made in accordance with the International Standard Methods (I.S.M., 1911).

Glycerol.—The standard shall be 80% Glycerol. Any Crude Glycerine tendered which tests 81% Glycerol or over shall be paid for at a *pro rata* increase, calculated as from the standard of 80%. Any Crude Glycerine which tests under 80% Glycerol, but is 78% or over, shall be subject to a reduction of 1½ times the shortage, calculated at *pro rata* price as from 80%. If the test falls below 78%, the buyer shall have the right of rejection.

Ash.—The standard shall be 10%. In the event of the percentage of Ash exceeding 10%, but not exceeding 10·5%, a percentage deduction shall be made for the excess calculated as from 10% at *pro rata* price, and if the percentage of Ash exceeds 10·5%, but does not exceed 11%, an additional percentage deduction shall be made equal to double the amount in excess of 10·5%. If the amount of Ash exceeds 11%, the buyer shall have the right to reject the parcel.

Organic Residue.—The standard shall be 3%. A percentage deduction shall be made of three times the amount in excess of the standard of 3%, calculated at *pro rata* price. The buyer shall have the right to reject any parcel which tests over 3·75%.

SAPONIFICATION CRUDE GLYCERINE.

Analysis to be made in accordance with the International Standard Methods (I.S.M., 1911).

Glycerol.—The standard shall be 88%. Any Crude Glycerine tendered which tests 89% or over shall be paid for at a *pro rata* increase, calculated as from the standard of 88%. Any Crude Glycerine which tests under 88%, but is 86% or over, shall be subject to a reduction of 1½ times the shortage, calculated at *pro rata* price as from 88%. If the test falls below 86%, the buyer shall have the right of rejection.

Ash.—The standard shall be 0·5%. In the event of the percentage of Ash exceeding 0·5%, but not exceeding 2·0%, a percentage deduction shall be made equal to double the amount in excess of 0·5%. If the amount of Ash exceeds 2·0% the buyer shall have the right to reject.

Organic Residue.—The standard shall be 1%. A percentage deduction shall be made of twice the amount in excess of the standard of 1%, calculated at *pro rata* price, with the right to reject any parcel which tests over 2%.

N.B.—The foregoing Standard Specifications were drawn up by the British Executive Committee on Crude Glycerine Analysis, and approved at a General Meeting of Crude Glycerine Makers, Buyers, and Brokers, held in the Whitehall Rooms, London, on October 3rd, 1912.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by Mr. John E. Raworth, *Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.*

14631/11. R. W. Wallace and E. Wassmer, London. **Phosphate Ores.** 20 June, 1911.

The method of treating phosphatic ores according to this invention, consists in distilling phosphorus therefrom in a closed furnace, electric or otherwise, and supplying air to the phosphorus vapour and other gases given off from the furnace in order to separate the oxygen (by combining with the phosphorus) from the nitrogen, and then separating the nitrogen from the other gases. (2 claims.)

15203/11. A. Fernbach, Paris, and E. H. Strange, London. **Products of Fermentation.** 29 June, 1911.

In the manufacture of products of fermentation, the fermentation is conducted in a closed vessel to which exhausting and condensing apparatus are connected, the exhausting apparatus being so operated that such a high degree of rarefaction is obtained in the fermentation vessel as will remove by vaporisation products of fermentation, which, if allowed to remain, would impede the fermentation. (2 claims.)

15204/11. A. Fernbach, Paris, and E. H. Strange, London. **Alcohol.** 29 June, 1911.

The higher alcohols are manufactured by mixing yeast with water (with or without a substance or substances containing carbohydrates), sterilising the mixture and adding tyrothrix tenuis or a ferment similar thereto (or an enzyme prepared therefrom), and also adding the butylic bacillus of Fitz or like ferment. (1 claim.)

16499/12. P. A. Newton, London. **Vat Dyestuffs.** 30 November, 1911.

This process for the production of new vat dyestuffs, consists in condensing one molecule of a compound consisting of two halogenated benzene residues coupled together simultaneously by O, S, or N H, and another group (with the exception of dihalogenated xanthones) with two molecules of an amino-anthraquinone, or of its acylamino derivatives. (2 claims.)

21151/11. J. Y. Johnson, London. **Ammonia.** 25 September, 1911.

Ammonia is manufactured by passing a mixture of hydrogen and nitrogen over a catalytic mixture containing a metal or metallic compound which has considerable power of taking up nitrogen, and also a metal or metallic compound which has considerable power of taking up hydrogen. (2 claims.)

21539/11. G. W. Johnson, London. **Zinc-sodium hydrosulphite.** 27 September, 1911.

A process for the production of a stable, high percentage and difficultly soluble zinc-sodium hydrosulphite, consists in first stirring together crude solutions of crude zinc hydrosulphite and of sodium hydrosulphite, heating the mixture, maintaining it in the heated condition, and then separating the precipitated salt from the mother liquor. (1 claim.)

22311/11. A. T. Cocking and Kynoch, Ltd., Birmingham. **Explosives.** 10 October, 1911.

A method of manufacturing high explosives of which nitro-glycerine is a preponderating constituent, consists in incorporating tri-nitrotoluene or tri-nitro-benzene with nitro-cotton, by bringing the former into contact with the latter suspended in water, and after any necessary digestion and drying, incorporating the resultant product with a preponderance of nitro-glycerine. (2 claims.)

22454 11. J. Y. Johnson, London. **Caoutchouc.** 11 October, 1911.

Substances resembling caoutchouc are manufactured by polymerising isoprene or other member of the same homologous series in the presence of oxidised caoutchouc or in the presence of from about 2 to 5% of the ozonide of isoprene or of a member of the same homologous series or of the ozonide of a terpene or similar body. (2 claims.)

799/12. O. Silberrad, London. **Purifying Nitro Compounds.** 10 January, 1912.

A process of purifying nitro compounds consists in admixing the same with a dilute solution of an alkaline material and maintaining said admixture in agitation and at a temperature of about from 50° to 70° C. for a considerable number of hours. (5 claims.)

3345/12. J. Y. Johnson, London. **Ammonia.** 9 February, 1912.

Ammonia is manufactured by passing nitrogen and hydrogen alternately, that is, successively and periodically, over an agent containing two or more metals (or compounds which, during the reaction, give rise to the metals) and capable of taking up nitrogen or hydrogen or both nitrogen and hydrogen. (4 claims.)

9293/12. A. G. Glasgow, London. **Water Gas.** 19 April, 1912.

In the process of making carburetted water gas wherein fuel gas produced by blasting a burning fuel bed is led through the fuel bed and burned with air to heat a separate chamber, the fuel bed being then steamed and the resultant gas passed through the heated chamber, the region of gas making activity of the fuel bed and the rate of storage of heat in the fuel bed and the rate of production of fuel gas are increased by introducing blasting air directly to the interior of the fuel bed, preferably above the ash level and below the top layer of comparatively cool fuel. (8 claims—4 Figs.)

2867/12. J. Effront, Brussels. **Ketones.** 3 February, 1912.

A process for the manufacture of ketones, according to this invention, consists in passing a mixture of vapours of concentrated fatty acid and water or vapours of diluted fatty acid through coke or charcoal maintained at a temperature of 350° to 450° C. (1 claim.)

16925/11. A. Fernbach, Paris, and E. H. Strange, London. **Fermentation Processes.** 24 July, 1911.

In fermentation processes there is added to the materials undergoing fermentation, nutrient medium prepared by causing a ferment, such as tyrothrix tenuis, or enzyme prepared therefrom, to act upon yeast. (1 claim.)

INDEX TO THE CHEMICAL WORLD,

January, 1912—December, 1912, inclusive.

Subject, Author, and Sectional.

A.

PAGE

- ABSORPTION of gases in vacuum tubes . . . 426
- Absorption photometry . . . 15, 48
- Acetic acid . . . 324
- Acids, American production of . . . 71
- Action of acids on concrete . . . 224, 297
- Adrenaline . . . 220
- Agricultural chemistry :—
  - Agricultural chemistry . . . 47, 260
  - Agricultural College for Devonshire . . . 348
  - Agricultural Department of Cambridge University . . . 335
  - Agricultural Research Scholarships . . . 384
  - Bordeaux mixture, the chemistry and fungicidal action of . . . 363
  - Candlilla wax . . . 287
  - Chemical characteristics of soils . . . 5
  - Coniferous woods, composition of . . . 193
  - Costs of sugar-beet cultivation . . . 102
  - Cultivation of beetroot . . . 101, 132
  - Diseases of vine and fruit trees . . . 278
  - Fertiliser exhibition in America . . . 142
  - Fertilisers, estimation of potassium in . . . 219
  - Fertilisers for tobacco growing . . . 64
  - Fungicidal action and chemistry of Bordeaux mixture . . . 363
  - Home-grown tobacco and sugar . . . 182
  - Nitrogen cycle in the soil . . . 185
  - Oxydases in plants . . . 259
  - Raw sugar, manufacture of . . . 277
  - Relation of oxydases to pigment formation in plants . . . 259
  - Scholarships, Agricultural Research . . . 348
  - Soil extracts and plant ashes, potassium in . . . 219
  - Soil humus . . . 260
  - Soil, lime in the . . . 47
  - Soil, the nitrogen cycle in the . . . 185
  - Soils, ammonia in . . . 287
  - Vine sickness . . . 278
- Air pump, a new . . . 164
- Alcohol for artificial silk, cheap . . . 431
- Alcohol, methyl in ethyl . . . 176
- Alkaline waters of the London basin . . . 299, 393
- Alkaloids . . . 3
- Alkaloids, synthesis of natural . . . 220
- Allotropy, dynamic . . . 305
- Allotropy of sulphur . . . 160, 231, 305
- Allotropy of tin . . . 377
- Aluminium in chemical industry . . . 232
- American honours for a German chemist . . . 106
- American mind, the . . . 2
- Ammonia evaporation and transformation in soils . . . 287
- Ammonium sulphate . . . 8
- Ammonium sulphate (world's production) . . . 35

PAGE

- Analyses of soot . . . 121
- Analysis :—
  - Analysis by electrolytic methods . . . 127
  - Analysis of food products . . . 310
  - Analysis of food stuffs . . . 253
  - Analysis of metallurgical materials, recent advances in . . . 297
  - Analysis of waters of the London basin . . . 393
  - Automatic analysis . . . 140
  - Automatic analysis for gases . . . 211
  - Chimney gases, estimation of lead in . . . 358
  - Density determinations by Specific Gravity Balls . . . 280
  - Detection of mydriatic alkaloids in toxicological practice . . . 3
  - Determination of ferrocyanides . . . 280
  - Electro-analysis . . . 53
  - Estimation of lead in chimney gases . . . 358
  - Estimation of potassium in fertilisers, soil extracts and plant ashes . . . 219
  - Fluorine, estimation of . . . 255
  - Gas analysis . . . 139
  - New methods of analysis 34, 65, 97, 140, 211, 247, 358
  - Nickel and cobalt, detection and estimation of . . . 247
  - Nitrates in water, estimation of . . . 247
  - Rapid analysis of copper . . . 65
  - Research in relation to analysis . . . 315
  - Scientific method in cellulose investigation . . . 223
  - Separation of liquid from solid fatty acids . . . 97
  - Tests for mechanical wood pulp in paper . . . 248
  - Water analysis by electrical conductivity . . . 26
- Animal grease, extraction of . . . 250
- Anthrax in the industries . . . 40
- Antiseptic treatment . . . 73
- Applied Chemistry, Eighth International Congress of . . . 382
- Armstrong, E. F. ("Enzymes") . . . 45, 92
- Armstrong, E. F. ("Essential Constituents of Food") . . . 147, 329
- Armstrong, E. F. (relation of oxydases to pigment formation in plants) . . . 259
- Arsenic . . . 162
- Arsenic compounds . . . 145
- Art, Science, and Industry . . . 110
- Artificial gems . . . 359
- Artificial precious stones . . . 79, 113
- Artificial silk . . . 215, 218
- Artificial silk for incandescent mantles . . . 322
- "Artificial Wool" . . . 178
- Atmospheric nitrogen . . . 322
- Atomised fuel, a water tube boiler for . . . 273

PAGE

- "Auto" carbon dioxide recorder . . . 212
- "Autolysator," The . . . 213

B.

- BACTERIA, investigation of the chemical action of . . . 403
- Balanced plunger pump . . . 59
- Baldwin, A. ("Thermo-regulator for Industrial Purposes") . . . 166
- Basic lead sulphate . . . 295
- Battersea Polytechnic . . . 92
- Beadle, C. (Latex Formation) . . . 261, 370, 409
- Beadle, C., and Stevens, H. P. ("Rubber and its Cultivation") . . . 119, 153
- Beet sugar factory, the chemistry of a . . . 277
- Beet sugar industry . . . 101, 131
- Beet sugar in Norfolk . . . 182
- Beilby, G. . . . 143
- Bennis, A. W. ("Efficiency in the Boiler House") . . . 103
- Berberine . . . 220
- Bermondsey, technical training at . . . 49
- "Bettington" boilers . . . 273
- Bi-meter carbon dioxide recorder . . . 213
- Biological chemistry :—
  - Bio-chemical research . . . 117, 192
  - Development of recent . . . 39
  - Examinations in . . . 322
  - Progress in . . . 10
  - (See also under "Enzymes" and the like).
- Birmingham, University of . . . 157
- Blakesley, T. H. (Density determinations by Specific Gravity Balls) . . . 280
- Bleaching of flour . . . 340
- Boiler House Efficiency . . . 103
- Bolton, E. R., and Revis, C. ("Oils, Fats, and Milk Products") . . . 14, 83, 192, 408
- Bomb calorimeters . . . 77
- Books received :— 32, 68, 100, 139, 176, 211, 247, 279, 318, 357, 390, 430
  - "Alkali Works, Forty-eighth Annual Report" (by Chief Inspector) . . . 318
  - "An Introduction to British Clays, Shales, and Sands" (Searle) . . . 247
  - "Annual Report of Recent Advances in Pharmaceutical Chemistry and Therapeutics" (E. Merck) . . . 416, 430
  - "Annual Tables of Constants and Numerical Data, Chemical, Physical and Technological" (Churchill) . . . 211
  - "Assaying and Metallurgical Analysis" (Rhead and Sexton) . . . 100
  - "Behaviour of Nitroglycerin when heated" (Snelling and Storm) . . . 318

PAGE

Books received—(*continued*)
  “ Bleaching and Dyeing of Vegetable Fibrous Materials ” (Hübner) 211
  “ Boilers, The Transmission of Heat into ” (Kreisinger and Ray) 357
  “ Calorific Power of Gas ” (Coste) 32, 68
  “ Cast Iron ” (Hatfield) . . 176
  “ Celluloid: Its Manufacture, Applications and Substitutes ” (Masselon, Roberts, and Cillard) 390
  “ Chemical Constitution of the Proteins ” (Plimmer and Hopkins) 279
  “ Chemical Research in its Bearings on National Welfare ” (Fisher) 390
  “ Chemical Works: their Design, Erection, and Equipment ” (Dyson and Clarkson) 211
  “ Chemistry of Bread Making ” (Grant) 68
  “ Chemistry of Coal Tar Dyes ” (Fay) 32
  “ Chemistry of the Rubber Industry ” (Potts) . . . 176
  “ Commercial Organic Analysis ” (Allen) 211
  “ Constituents of Coal Soluble in Phenol ” (Fraser and Hoffman) 318
  “ Deterioration and Spontaneous Heating of Coal in Storage ” (Porter and Ovitz) . . 318
  “ Dictionary of Applied Chemistry ” (Thorpe) . 100, 211
  “ Die Existenz der Moleküle ” (Svedberg) 357
  “ Dyeing and Cleaning ” (Farrell) 430
  “ Effect of Stemming on the Efficiency of Explosives ” (Snelling and Hall) . . . 430
  “ Einführung in die Qualitative Chemische Analyse ” (Wiechowski) 357
  “ Elementary Chemical Theory and Calculations ” (Knox) . 390
  “ Elementary Text Book of Metallurgy ” (Sexton) . . 68
  “ Elements of Qualitative Chemical Analysis ” (Stieglitz) 390
  “ Exercises in Chemical Calculation ” (Coward and Perkins) 247
  “ Experimental Course of Physical Chemistry “ (Spencer) 100
  “ Factor of Safety in Mine Electrical Installations ” (Clark) 318
  “ Fatty Foods: Their Practical Examination ” (Bolton and Revis) 430
  “ First Annual Report of the Director of the Bureau of Mines ” 318
  “ Gas Analysis as an Aid in Fighting Mine Fires ” (Burrell and Seibert) 318
  “ General Foundry Practice ” (McWilliam and Longmuir) . 247
  “ Higher Mathematics for Chemical Students ” (Partington) 32
  “ Ignition of Gas by Miniature Electric Lamps with Tungsten Filaments ” (Clark) . . 357
  “ Inorganic Chemistry for Beginners ” (Roscoe and Lunt) . 211

PAGE

Books received—(*continued*)
  “ Introduction à l’Étude de la Spectrochimie ” (Urbain) . 68
  “ Introduction to the Study of Fuel ” (Brislee) 176
  “ Laboratory Book of Mineral Oil Testing ” (Hicks) . . . 279
  “ Leçons de Cristallographie ” (Friedel) 68, 389
  “ Lectures on Cellulose ” (Cross) 211
  “ L’histoire de la Chimie ” (Colson) 100
  “ Liquefied Products from Natural Gas: Their Properties and Uses ” (Allen and Burrell) 318
  “ Lubrication and Lubricants ” (Archbutt and Deeley) . . 279
  “ Magazines and Thaw Houses for Explosives ” (Hall and Howell) 430
  “ Manufacture of Chemical Manures ” (Fritsch) . . . 32
  “ Manufacture of Nitro-Lignin and Sporting Powder ” (Durnford) 176
  “ Manufacture of Sulphate of Ammonia ” (Calvert) . . . 68
  “ Metallurgy ” (Borchers) . . 68
  “ Methods of Air Analysis ” (Haldane) 176
  “ Methods of Analysing Coal and Coke ” (Stanton and Fielden) 279
  “ Methods of Organic Analysis ” (Sherman) 318
  “ Methods of Sugar Analysis and Allied Determinations ” (Given) 279
  “ Microbiology ” (Marshall) . 68
  “ Micropetrology for Beginners ” (Rhodes) . . . 100
  “ Modern Copper Smelting ” (Levy) 279
  “ Modern Inorganic Chemistry ” (Meller) 430
  “ Modern Research in Organic Chemistry ” (Pope) . 390
  “ Nitro-Cellulose Industry ” (Worden) 32
  “ Notes on Foundry Practice ” (Morgan) 357
  “ Notes on Mineral Wastes ” (Parsons) 430
  “ Oxidations and Reductions in the Animal Body ” (Dakin) . 390
  “ Permissible Explosives and Precautions to be taken in their Use ” (Hall) . . . 318
  “ Practical Cotton Finishing ” (Edge) 32
  “ Preparation of Organic Compounds ” (Barnett) . . 430
  “ Public Health Chemistry and Bacteriology ” (McKail) . . 211
  “ Qualitative Chemical Analysis of Inorganic Substances ” (Tower) 100
  “ Química Moderna Teórica y Sistematica ” (Ramsay) . . 357
  “ Researches on Cellulose ” (Cross and Bevan) . . . 318
  “ Scheme for the Detection of the more Common Classes of Carbon Compounds ” (Weston) 318
  “ School Chemistry ” (Wilson and Hedley) 100
  “ Science Progress ” . . 32, 139
  “ Second Stage Inorganic Chemistry, Theoretical ” . 430
  “ Second Year Course of Organic Chemistry for Technical Institutes ” (Thole) 390

PAGE

Books received—(*continued*)
  “ Simple Carbohydrates and the Glucosides ” (Armstrong) 390
  “ Slagging Type of Gas Producer ” (Smith) 318
  “ Smoke ” (Cohen and Ruston) 176
  “ Soil Conditions and Plant Growth ” (Russell) . . . 318
  “ Some Chemical Problems of To-day ” (Duncan) . . 32, 67
  “ Some Stream Waters of the Western United States ” (Stabler) 176
  “ Status of the Gas Producer in the Utilisation of Fuels ” (Fernald) 318
  “ Technology of Bread-making ” (Jago) 139
  “ Technology of Iron Enamelling and Tinning ” (Grünwald) 318
  “ Testing of Wood Pulp ” (Sindall and Bacon) . . . 318
  “ Text Book of Practical Chemistry for Technical Institutes ” (Dunstan and Thole) 68
  “ The Analyst’s Laboratory Companion ” (Johnson) . . 211
  “ Theorie und Praxis des Mahlens ” (Beadle and Stevens) 211
  “ Theories of Solutions ” (Svante Arrhenius) . . . 390
  “ Traité Complet d’Analyse Chimique Appliquée aux Essais Industriels ” (Post and Neumann) 68
  “ Trattato di Chimica Inorganica Generale e Applicata all’ Industria ” (Molinari) . 430
  “ Treatise on General and Industrial Inorganic Chemistry ” (Molinari) 390
  “ Treatment of Effluents from Dye-houses and Textile Factories ” (Garner) . . . 357
  “ Use of Mice and Birds for Detecting Carbon Monoxide after Mine Fires and Explosions ” (Burrell) 318
  “ Volumetric Analysis ” (Hampshire) 176
  “ Water Analysis ” (Stocks) . 176
  “ Who’s Who in Science ” (Stephenson) 68
Borough councils 110
Bousfield, W. R. (“ Notes on Two Thermo Regulators ”) 33
Bradford Technical College . . . 195
Breakage of steel rails 392
Bricks, Lime-silica 13
Briggs, J. F. (“ Coniferous Woods ”) 193
Briggs, J. F. (“ Some Aspects of the Resin and Wood Pulp Industries ”) 369
Bristol University, Chemical Department 411
Butter, milk powder in 163

C.

CALORIFIC power of fuels . . 75, 273
Cambridge University, Chemical Department 85
Cambridge University, Department of Agriculture 335
Camphor industry in Formosa . . 334
Camphor in East African Protectorate 106
Cancer and the Chemist 38
Caoutchouc 119
Carbon dioxide estimation, automatic apparatus for 140
Carbon dioxide Recorders . . . 211

PAGE

- Carbonate of soda in natural waters and mineral deposits, origin of . 15
- Carborundum manufacture in Norway 287
- Carpenter, H. C. H. (" Permanent 'Growth' of Cast Irons ") 291
- Carpenter, H. C. H. (" The Critical Point at 470° C. in Copper Zinc Alloys ") 172
- Carr, F. H. (" Detection of Mydriatic Alkaloids in Toxicological Practice ") 3
- Carr, F. H. (" Technological Training ") 272
- Carter, S. R., and McCombie, H. (" University of Birmingham ") 157
- Casein 353
- Cast iron, growth of 291
- Catalytic action of metallic oxides on primary alcohols 151
- Catalytic action of reduced metals 78
- Catalytic agents, influence of 306
- Celluloid, dangers of 215
- Celluloid substitutes 178
- Cellulose 70
- Cellulose and cellulose products 13
- Cellulose, formylated 407
- Cellulose investigation, scientific method in 84, 223, 333
- Cement, the constitution of Portland 405
- Centrifugal pump for unscreened sewage 205
- Cereals, analysis of 310
- Chemical constitution, the determination of 415
- Chemical crystallography 399
- Chemical engineering, classes in 282
- Chemical fertilisers, effect on tobacco crops 65
- Chemical industry in Germany in 1911 359
- Chemical injector, a new 133
- Chemical Laboratories :—
  - Birmingham University 157
  - Bradford Technical College 195
  - Bristol University 411
  - Cambridge University 85
  - City and Guilds of London Central Technical College, Finsbury 373
  - Government Analytical, London 263
  - Imperial Institute, London 227
  - Leathersellers' Company's Technical College, Bermondsey 49
  - Liverpool University 301
  - Royal College of Science, London 17
- Chemical manures in Austria, demand for 105
- Chemical purification of drinking water 82
- Chemical research. See Research, Chemical.
- Chemistry :—
  - Agricultural. See Agricultural Chemistry.
  - Biological. See Biological Chemistry.
  - Electro-. See Electro-Chemistry.
  - Metallurgical. See Metallurgical Chemistry.
- Chemistry and physics of colloids 23, 54, 90, 135, 170, 208, 243, 283, 313, 346, 391, 427
- Chemistry of the lead chamber process 339
- Chrome leather, neutralisation of 286
- Cinchona bark industry (Ceylon) 182
- Clay, the mechanical and chemical effects of water on 117
- Clayton, A. (" Catalytic Action of Metallic Oxides on Primary Alcohols ") 151
- Clayton, A. (" Synthesis of Natural Alkaloids ") 220
- Clayton, A. (" The Catalytic Action of Reduced Metals ") 78
- Clayton, A. (" The Recent Progress of Organic Chemistry ") 9
- Cleansing action of soap 46
- Clyde River, state of 154
- Coal tar products in Germany, value of 395
- Coating metal surfaces 25
- Cobalt and chromium, optically active compounds of 187
- Cohen, J. B. (" Soot : Its Character and Effects ") 121
- Cohen, J. B. (" The Terpenes "). 331, 365
- Colleges. See Universities.
- Colloidal metallic sulphides in rubber solutions 194
- Colloids in the soil 260
- Colloids, the physics and chemistry of 23, 54, 90, 135, 170, 208, 243, 283, 313, 346, 391, 427
- Combined nitrogen in rain 155
- Combustion recorders, automatic 140, 211
- Commercial and Industrial Notes 35, 70, 105, 140, 178, 214, 250, 286, 322, 359, 394, 430
  - Accident prevention 142
  - Adulteration of oils 250
  - America, potash discoveries in 35
  - America's acid production 71
  - American export developments 35
  - American fertilizer exhibition 142
  - Argentine markets for chemicals and paints 105
  - Artificial graphite 394
  - Artificial silk 215
  - Artificial silk, a new concern 395
  - Artificial silk, cheap alcohol for German manufacturers of 431
  - Artificial silk, financial results 323
  - Austria, chemical industry in 215
  - Austria, demand for chemical manures in 105
  - Austria's monopoly as a producer of radium 178
  - Berlin Radium Institute 323
  - British standard specification for soap lye and saponification crude glycerine 431
  - Calcium cyanamide for extraction of ores 142
  - Canada as a market for insecticides 286
  - Canada, peat in 296
  - Celluloid dangers 215
  - Chemical duties in the United States, projected alteration of 141
  - Chemical industry developments in Japan 142
  - Chemical industry in Germany 287
  - Coalite, Limited 282
  - Continental chemical firms, profits of 215
  - Danish margarine industry 430
  - Development of Germany's indigo export trade 35
  - East African Protectorate, camphor in 106
  - Extraction of animal grease 250
  - Fertilizers in Finland 215
  - Financial notes 282
  - Financial results of leading chemical firms 179
  - Finland, fertilizers duty free into 215
  - Formosa, camphor industry in 334
  - German chemical firm and French Government 430

PAGE

- Commercial Notes—(*continued*)
  - German coal tar products 395
  - German Glycerine Convention 71
  - German industrial developments 287
  - German industrial enterprises 316
  - German nitrates, dissolution of syndicate 394
  - Germany's chemical trade in 1911 141
  - Germany's indigo industry 35
  - Glycerine, market prices of 201
  - Heniquin waste for production of alcohol 142
  - I. S. M., 1911, adopted in Germany 71
  - Ibean camphor tree 106
  - India, natural indigo industry in 251
  - International Technical Convention for Industrial Hygiene 142
  - Japan, development of the chemical industry in 142
  - Japan, sulphur mining in 179
  - Japan, wood alcohol trade in 359
  - Japanese peppermint oil industry 382
  - Jute, a new substitute for 214
  - Leadless paint award 106
  - Madagascar, red mangrove bark in 167
  - Manganese and phosphate 316
  - Mineral gas for production of nitrogen from the air 179
  - Mond Nickel Co. 282
  - Natural indigo industry in India 251
  - New Brunswick, ammonium sulphate in 105
  - New laboratories in Austria 286
  - Nitrogen as a bye-product of aluminium manufacture 105
  - Norwegian carborundum manufacture 287
  - Notes on essential oils, trade 395
  - Oleomargarine in United States, new tax on 71
  - Origin of holes in Swiss cheese 395
  - Paint destroying fungus 106
  - Paint from " wet gas " 369
  - Perfumes for soaps 214
  - Philippines yield oil of petitgrain 395
  - Pine tar for denaturing olive oil 394
  - Potash question in America 71
  - Production of white lead 323
  - Radium deposits in Budapest 105
  - Russia, radio-active minerals in 359
  - Seaweed, treatment for commercial purposes 282
  - Sharpening files 323
  - Shellac, use in food products 142
  - Sicilian sulphur production and trade 430
  - Sicilian tunny oil 323
  - Silk imports statistics 110
  - Soya beans in Argentina 250
  - Spirit monopoly in Germany 251
  - Sulphate of ammonia 35
  - Synthetic rubies and sapphires 359
  - Textile machinery 316
  - Textile material, a new 178
  - Toilet preparations, peroxide in 431
  - United States chemical duties 141
  - United States, first potash plant in 179
  - Venezuela, potash salts in 179
  - Waste liquor from starch factories, utilisation of 286
  - Waste soda liquors, soap from 394

PAGE
Commercial Notes—(*continued*)
    Waterproofing material for fishing nets, etc. 214
    White lead production . . . 323
Concrete, action of acids on . . 224, 297
Constitution, the determination of chemical 415
Copper, rapid analysis of 65
Copper refining electrolytically . . 343
Copper-zinc alloys, the critical point at 470° C. in 172
Correspondence :—
    Chemical technology in colleges 272
    Metric system, the 66
Corrosion Research, Institute of Metals 122
Corundum 80
Coste, J. H. ("Fuel Calorimetry") 75
Cross, C. F. ("Cellulose amd Cellulose Products") 13
Cross, C. F. ("Scientific Method in Cellulose Investigation") . 84, 223, 333
Cryolites 168
Crystallography, chemical . . . 399
Cultivation of rubber . . . 119, 153
Current legal topics. See Legal Intelligence.
Cyanamide. 322

D.

Darbishire, F. V. ("The Chemistry of a Beet Sugar Factory") . . 277
Davis, J. G. ("A New Chemical Injector") 133
Davis, J. G. ("A Useful Pump") . 59
Davis, J. G. ("A Water Tube Boiler for Atomised Fuel") 273
Davis, J. G. ("Internal Combustion Pumps and Compressors") . . 319
Davis, J. G. ("Non-Ferrous Metals") 234
Davis, J. G. ("The 'Dionic' Water Tester") 26
Davis, J. G. ("The *Stereophagus* Pump") 205
Davis, W. A. ("Estimation of Potassium") 219
Davis, W. A ("Recent Improvements in Vacuum Evaporation"). 423
Dead languages, teaching of . . . 74
Deaths by industrial poisoning . . 111
Decay of tin 377
Decomposition of nitric oxide by pressure 351
Degrees, value of 384
Deliming of hides 285
Desch, C. H. ("The Constitution of Portland Cement") 405
Diamonds 80
Diastase, production during flooring 296
"*Dionic* Water Tester" 26
Distribution of fluorine in animal and vegetable tissues 255
Dorta, W., and Fachini, S. ("Separation of Liquid from Solid Fatty Acids") 97
Douglas, L. M. ("The Food Products of Rhodesia") 309, 349
Dowling, R. N. ("Notes on the Sugar-Beet Industry") . . 101, 131
Dreaper, W. P. ("Coating Metal Surfaces") 25
Dreaper, W. P. ("Notes on Chemical Research") . 27, 60, 93, 129, 177, 203, 245, 281, 353, 381
Drinking water, chemical purification of 83
Dryer efficiency 275
Dyeing, the electrical theory of . . 267
Dynamic allotropy in gaseous and liquid sulphur 305

E.

PAGE
Educational methods 2
"Efficiency in the Boiler House" . 103
Efficiency of dryers 275
Electric steel 116
Electrical conductivity of water . 26
Electrical theory of dyeing . . . 267
Electro-Chemistry :—
    Action of organic and inorganic substances in the bath . . 118
    Addition agents and electrolytes 118
    Electro-analysis, present position of 53, 127
    Electro-chemical production of ozone 380
    Electrolytic copper refining industry 343
    Progress in electro-chemistry . 46
Elementary mathematics . . . 2
"Enamel Industry, the Influence of the Chemist upon the" . . . 168
Enzyme action, synthesis by . . 117
Enzymes 45
Enzymes, action of 332
Enzymes and inhabitants . . . 192
Essential constituents of food . 147, 329
Essential oils, adulteration of . . 250
Etching by fluorine 255
Ethyl acetoacetate 9
Eucalyptus oil for ore concentrating 71
Evaporation and concentration of solutions 200
Excess lime method for sterilising drinking waters 225
Exhibition of non-ferrous metals at Olympia 234

F.

Fachini, S., and Dorta, W. ("Separation of Liquid from Solid Fatty Acids") 97
Farming in Rhodesia . . . 309, 349
Fatty acids of olive oil 98
Feilmann, E. ("On the Cleansing Action of Soap") 46
Ferrocyanides, determination of . 280
Ferrocyanides of the heavy metals, pure 43
Fertilizer trade in Japan, regulations for 368
Fertilizers 67
Fish-oil refining in Japan . . . 251
Flax, paper from 258
Flour, analysis of 269
Flour, bleaching 340
Fluorine in animal and vegetable tissues 255
Fogg, F. G. ("Gas Producers and Gas-fired Furnaces") 385, 419
Food adulteration 417
"Food and Drugs Acts and a Court of Reference" 24
Food crops of Rhodesia 310
Food products of Rhodesia . . 309, 349
Food, the essential constituents of . 147, 329
Formylated cellulose 407
Frankland, P. F. 157
Fuel calorimetry 75
Fuel losses 116
Fuels, analyses and calorific values . 275
Fused potassium hydroxide . . . 402
Fusion-welding 25

G.

Gardner, W. M. ("Bradford Technical College") 195
"Gas-fired Furnaces" 385, 419
"Gas Producer Plants" (Mond) . . 235

PAGE
"Gas Producers and Gas-fired Furnaces" 385, 419
"Gels in Relation to Ore Deposition" 189
Gems, artificial 18, 113
General notes. See Commercial and Industrial Notes.
German Universities 362
Germany, higher education in . . 218
Gimingham, C. T. ("Combined Nitrogen in Rain") 155
Gimingham, C. T. ("Soil Humus") . 260
Gimingham, C. T. ("The Chemistry and Fungicidal Action of Bordeaux Mixture") 363
Gimingham, C. T. ("The Functions of Lime in the Soil") 47
Glasgow sewage purification . . 154
Glycerine, market prices of . . . 201
Gold ore 190
Graphite, artificial 394

H.

Hale, A. J., Meldola, R., and Thompson, H. V. ("Isopicramic Acid") 327
Hancock, W. C. ("Action of Acids on Concrete") 224, 297
Hancock, W. C. ("Lime-Silica Bricks") 13
Hancock, W. C. ("Mechanical and Chemical Effects of Water on Clay") 117
Harden, A. ("Bio-Chemistry") . 117, 192
Harden, A. ("Progress in Bio-Chemistry") 10
Harden, A. ("The Investigation of the Chemical Action of Bacteria") 403
Harden, A. ("The Recent Development of Biological Chemistry") . 39
Hardness of London waters . . . 394
Harrison, L. H. ("The 'Permutit' Water Softener") 238
Harrison, W. ("The Electrical Theory of Dyeing") 267
Hatschek, E. ("The Physics and Chemistry of Colloids") . 23, 54, 90, 135, 170, 208, 243, 283, 313, 346, 391, 427
Hatschek, E., and Simon, A. L. ("Gels in Relation to Ore Deposition") . 189
Heaton, N. ("Artificial Precious Stones") 79, 113
Heusler alloys 271
Higher education in Germany . . 218
Hodgson, H. H. ("Influence of the Chemist upon the Enamel Industry") 168
Holloway, G. T. ("Meeting of Scientific and Technical Societies in Cornwall") 311
Holloway, G. T. ("Metallurgical Progress in 1911") 11
Holloway, G. T. ("Non-Ferrous Metals") 183
Humphrey pump, the 319
Hyoscine 4, 162

I.

"Ice at 76° C." 41
"Ice, Water, and Steam" . . . 169
Imperial Institute, Technical Department of the 227
Imports of platinum 356
Imports, silk 110
Incandescent mantles, artificial silk for 322
Indicator, isopicramic acid as an . 327
Indigo exports from Germany . . 35
Indigo industry 251
Industrial casein 353

PAGE

- Industrial conditions in America . 67
- Industrial lead poisoning . . . 111
- Industrial notes. See Commercial and Industrial Notes.
- Injection of chemical solution by automatic means 133
- Insecticides, Canadian markets for . 286
- Insoluble sulphur 305
- Institutions. See Societies.
- "Internal Combustion Pumps and Compressors" 319
- Iron and nickel, passivity of . . 334
- Isomorphism of sulphur, selenium, and tellurium 231
- Isopicramic acid as an indicator. . 327

J.

- Jago, W. (Current Legal Topics) . 24, 96, 162, 269, 340, 417
- Jobling E. ("Cobalt and Chromium Compounds") 187
- Jobling, E. ("The Chemistry of the Lead Chamber Process") . . . 339
- Jute 249

K.

- Kaiser-Wilhelm Institute . . . 362
- Keane, C. A. ("Automatic Analysis") 140, 211
- Kershaw, J. B. C. ("Smoke Abatement") 115
- Kershaw, J. B. C. ("Surface Combustion") 198
- Kershaw, J. B. C. ("The Autumn Meeting of the Iron and Steel Institute") 392
- Kershaw, J. B. C. ("The Electrolytic Copper Refining Industry") . . 343
- Kinematograph in college and school 38
- Klein, C. A. ("Industrial Lead Poisoning") 111
- Klein, C. A. ("Modern White Pigments") 293
- Knight, H. F. ("New Methods of Analysis") 34, 65, 247

L.

- Lamb, M. C. ("The Leathersellers' Company's Technical College, Bermondsey") 49
- Latex formation . . 120, 261, 370, 409
- Lead chamber process, the chemistry of the 339
- Lead in chimney gases, estimation of 358
- "Lead Poisoning" 111
- Leading Articles :—
  - American Mind, the . . . 2
  - August 12th, 1865 73
  - British Science Guild . . . 217
  - Building Fund, Institute of Chemistry 325
  - Chemist or Pharmacist . . . 399
  - Future fuel supply 145
  - Imperial College of Science and Technology and Mathematics 361
  - Industrial Scholarships . 37, 67
  - Institute of Chemistry Building Fund 325
  - Manufacturer and Chemist. . 253
  - Mathematics and the Imperial College 361
  - New Chemistry, the. . . . 289
  - Non-ferrous Metals Exhibition . 181
  - Professional Question, a. . . 109
  - Royal Commission, a . . . 398
  - Scholarships, industrial . . 37, 67
- Leather manufacture 52
- Legal Intelligence :
  - Adulteration of food . . . 417
  - Bleaching of flour 269
  - "Court of Reference and Food and Drugs Acts" 24
  - Flour bleaching 340
  - Flour destruction case . . . 162
  - Milk powder in butter . . . 163
  - Samples in patent applications . 96
  - *Seddon, Rex* v. 162
- "Life, Origin of" 326
- Lime in the soil, the functions of . 47
- Lime in water purification . . . 225
- Lime-silica bricks 13
- Liquids under tension 156
- Lister, Lord 73
- Lithopone 296
- Liverpool University, Chemical Department. 301
- Lowry, T. M. ("Ice at 76° C.") . . 169
- Lowry, T. M. ("Ice, Water, and Steam") 41
- Lowry, T. M. ("The Allotropy of Sulphur") . . . 160, 231, 305
- Lowry, T. M. ("The Allotropy of Tin : *Tin-Pest*") 377

M.

- McBain, J. W. ("The Chemical Department of the University of Bristol") 411
- McCombie, H., and Carter, S. R. ("University of Birmingham") . 157
- Magnetic susceptibility 221
- Margarine industry in Denmark . . 430
- Martin, G. ("Industrial Casein") . 353
- Mathematics, elementary . . . 2
- Mechanical stokers 103
- Mees, K. ("Absorption Photometry") 15, 48
- Meetings. See Societies.
- Meldola, R., Hale, A. J., and Thompson, H. V. ("Isopicramic Acid and its Use as an Indicator") . . 327
- Mercury industry 324
- Merz, E., and Wrede, H. ("Tests for Mechanical Wood Pulp in Paper") 248
- Metal sheet casting 57
- Metallurgical Chemistry, etc. :—
  - Alloys, Heusler 271
  - Alloys, nomenclature of . . 48
  - Alloys, the critical point in zinc-copper 172
  - Alloys, vaporisation of . . . 258
  - Critical point in copper-zinc alloys 172
  - Gold ore 190
  - Metallography, present developments of 149
  - Metallurgical materials, analysis of 297
  - Metallurgical operations . . 281
  - Metallurgical processes by surface combustion 200
  - Metallurgical progress in 1911 11
  - "Metallurgy of the non-ferrous metals" 183
  - Non-ferrous metals, metallurgy of 183
  - Ore concentration by eucalyptus oil 71
  - "Ore deposition, gels in relation to" 189
  - Ore extraction by calcium cyanamide 142
  - Physical metallurgy . . . 149
  - Volatility of metals 116
  - "Volatility of metals *in vacuo*" 257
  - Volatisation of metals *in vacuo* . 48
- Methyl alcohol in ethyl alcohol . . 176
- Milk products 14, 83, 192
- Mineral ingredients in rubber . . 59
- "Modern White Pigments" . . . 293
- Molecular weight of soluble sulphur 305
- Mond, "Gas for Power and Heating" 235
- Monier-Williams, G. W. ("The Distribution of Fluorine in Animal and Vegetable Tissues and its Estimation in Minute Quantities") 255
- Municipal chemistry 156
- "Mydriatic alkaloids in toxicological practice, detection of" 3

N.

- "Negative pressure in liquids" . 155
- Nickel and iron, passivity of . . 334
- Nicotine 220
- Nitric oxide decomposed by pressure 351
- Nitrites in Germany 394
- Nitogen from the air, mineral gas used for producing 179
- Nitrogen in rain, combined . . . 155
- Nitrolim 67
- Nobel Prize 428
- Nomenclature of alloys 48
- Non-ferrous Metals Exhibition . 32, 234
- Notes. See Personal and other Notes ; Commercial and Industrial Notes, etc.

O.

- Obituary :—
  - Divers, E. 163
  - Frühling, R. 207
  - Jones, H. O. 300, 384
  - Lister, Lord 92, 207
  - Pullar, Sir R. 428
- Oil fuel 145
- Oil of petitgrain from the Philippines 395
- "Oils, Fats, and Milk Products" 14, 83, 192
- Opaque stones 114
- Opium alkaloids 220
- Optics and chemistry 254
- Organic chemistry, recent progress of 9
- "Origin of life" 326
- "Our Programme" 1
- Ozone produced electro-chemically . 380
- Ozonized oil of turpentine . . . 359

P.

- Paper, tests for mechanical wood pulp in 248
- Paper-making plant 316
- Para rubber 153
- Pascal's magnetic researches . . 222
- "Passivity of iron and nickel" . . 334
- Pasteur 73
- Patent, protection by 381
- Patent Record . 36, 72, 108, 144, 180, 216, 252, 288, 324, 360, 396, 432
  - Ageing beverages 36
  - Alcohol 432
  - Alkali cyanides 396
  - Alloys, zinc 288
  - Aluminium nitride 360
  - Ammonia 432
  - Ammonium chloride . . . 216
  - Ammonium nitrate 36
  - Artificial leather 180
  - Artificial paving 108
  - Artificial rubber 180
  - Artificial stone 108, 252
  - Asbestos, purification of . . 288
  - Blasting explosives 288
  - Caoutchouc 432

- Patent Record—(*continued*)
  - Carbonaceous materials, distillation of . . . 324
  - Celluloid substitutes . . . 180
  - Cellulose compounds . . . 288
  - Chrome leather . . . 144
  - Collodion or celluloid composition . . . 36
  - Copper compounds . . . 252
  - Copper liquors, treatment of . . . 216
  - Copper treatment . . . 108
  - Cyanamide . . . 396
  - Dietetical products . . . 396
  - Distillation of carbonaceous materials . . . 324
  - Distillery wash, treatment of . . . 288
  - Distilling ammoniacal liquors . . . 252
  - Distilling process . . . 396
  - Dyes . . . 396
  - Emulsifying asphalt . . . 72
  - Explosives . . . 144, 432
  - Explosives for blasting . . . 288
  - Fermentation processes . . . 432
  - Flour purification . . . 252
  - Flour, treatment of . . . 252
  - Gas purification . . . 252
  - Glucose-like product . . . 108
  - Glycerophosphates . . . 288
  - Glycerophosphoric acid . . . 252
  - Guncotton . . . 144
  - Illuminating gas . . . 252
  - Imitation marble . . . 72
  - Indiarubber extraction . . . 108
  - Indigo dyeing . . . 72
  - Isoprene . . . 324, 396
  - Ketones . . . 216, 432
  - Leather treatment . . . 144, 216
  - Manufacture of fuel . . . 396
  - Manufacture of sodium and potassium . . . 36
  - Manufacture of sterile butter and cream . . . 252
  - Margarine . . . 396
  - Metallic sodium . . . 108
  - Metallurgy of zinc . . . 360
  - Molybdenum nitride . . . 216
  - Nickel copper mattes . . . 324
  - Nitrogen compounds . . . 72, 108, 360
  - Ore treatment . . . 396
  - Oxygen production . . . 288
  - Paper manufacture . . . 360
  - Phosphate ores . . . 432
  - Preservation of wood . . . 36
  - Production of zinc . . . 36
  - Products of fermentation . . . 432
  - Purifying gases . . . 72
  - Purifying nitro compounds . . . 432
  - Purifying rubber . . . 396
  - Pyrometers . . . 324
  - Reclaiming rubber waste . . . 144, 252
  - Recovery of tin . . . 360
  - Red mono-azo-dyestuff . . . 288
  - Regenerating rubber . . . 180
  - Resin soap . . . 360
  - Rubber substitutes . . . 216
  - Salt, manufacture of . . . 324
  - Seasoning timber . . . 360
  - Sewage treatment . . . 108, 252
  - Sintering fine ores . . . 324
  - Soda lye purification . . . 108
  - Solidified petroleum . . . 180
  - Sterilising and preserving milk . . . 144
  - Sterilising milk . . . 72
  - Sterilising water . . . 396
  - Sulphur . . . 496
  - Sulphur recovery . . . 360
  - Sulphuric acid . . . 108, 216, 324
  - Synthetic caoutchouc . . . 36
  - Testing air . . . 72
  - Tin recovery from ores . . . 216
  - Treatment of coal gas . . . 36
  - Treatment of fermentable substances . . . 180
  - Treatment of latex . . . 144
- Patent Record—(*continued*)
  - Vanadium and like compounds . . . 72
  - Vat dyestuffs . . . 432
  - Waste rubber treatment . . . 180
  - Water gas . . . 432
  - White pigments . . . 72
  - Zinc . . . 252, 360
  - Zinc alloys . . . 288
  - Zinc distillation . . . 36
  - Zinc-sodium hydrosulphite . . . 432
- Patents for chemical inventions, samples in cases of applications for . . . 96
- "Pay of the Public Analyst" . . . 134
- Peat in Canada . . . 296
- Peppermint oil industry in Japan . . . 382
- Perkin, F. M. ("Action of Organic and Inorganic Substances in the Bath") . . . 118
- Perkin, F. M. ("Progress in Electrochemistry") . . . 46
- "Permanent *Growth* of Cast Irons after Repeated Heatings" . . . 291
- "*Permutit* System of Water Treatment" . . . 238
- Peroxide in toilet preparations . . . 431
- Perry, J. ("Problems in Technical Education") . . . 307
- Personal and other Notes . . . 62, 92, 137, 163, 207, 244, 280, 322, 348, 384, 428
- Philip, J. C. ("The Chemical Department of the Royal College of Science") . . . 17
- Photo-chemistry . . . 15, 48
- Photometer, a new hand . . . 246
- Photometry, absorption . . . 15, 48
- Physics and chemistry of colloids . . . 23, 54, 90, 135, 170, 208, 243, 283, 313, 346, 391, 427
- Pickard, J. A. ("Analysis of Metallurgical Materials") . . . 297
- Pigment formation in plants . . . 259
- Pigments . . . 138
- Platinum . . . 354
- Platinum, average prices of . . . 354
- Platinum, volatility of . . . 116
- Poisoning, arsenical . . . 122, 162
- Poisoning, lead . . . 111
- Polymorphism . . . 150
- Polymorphism and polymerism . . . 232
- Ponder, C. ("Anthrax in the Industries") . . . 40
- Portland cement . . . 8, 224
- Portland cement, the constitution of . . . 405
- Portraits:—
  - Dobbie, J. J. . . . 263
  - Dunstan, W. . . . 227
  - Francis, F. . . . 411
  - Frankland, P. F. . . . 157
  - Meldola, R. . . . 373
  - Pope, W. J. . . . 85
  - Ramsay, Sir W. . . . 123
  - Thorpe, Sir E. . . . 17
- Potash discoveries in America . . . 35
- Potash plant in the United States . . . 179
- Potash salts in Venezuela . . . 179
- "Potassium in fertilisers, soil extracts and plant ashes, estimation of" . . . 219
- Poynor, F. W. ("Dryer Efficiency") . . . 275
- Precious stones, artificial . . . 79, 113
- Precious stones, composition of . . . 80
- Preparation of isopicramic acid . . . 327
- Prices of platinum . . . 354
- Primary alcohols, catalytic action of metallic oxides on . . . 151
- Proctor Research Laboratory . . . 362
- "Producer Gas," Mond . . . 235
- "Production of pure ferrocyanides of the heavy metals" . . . 43
- Programme, Our . . . 1
- Progress . . . 145
- Proteins . . . 147, 349
- Prud'homme, Maurice . . . 287
- Public Analyst, the pay of the . . . 134
- Public health and food . . . 417
- Public Schools . . . 290
- Pulp from flax stalks . . . 258
- "Pump, a useful" . . . 59
- Purification of drinking waters by lime . . . 225
- Purification of Glasgow sewage, and the state of the lower Clyde . . . 154

R.

- RADIO-ACTIVE minerals in Russia . . . 359
- Radium, Austrian monopoly in . . . 178
- Radium Institute, the Berlin . . . 323
- Rail breakage . . . 392
- Rain, combined nitrogen in . . . 155
- Raleigh, Lord . . . 124
- Rapid evaporation . . . 423
- Raw rubber . . . 119
- Raworth, J. E. . . . 36, 72, 108, 144, 180, 216, 252, 288, 324, 360, 396, 432
- Recent progress of organic chemistry . . . 9
- Red mangrove bark in Madagascar . . . 167
- Refining of copper electrolytically . . . 343
- Regulations for fertilizer trade in Japan . . . 368
- Regulations for wood alcohol trade in Japan . . . 359
- Research:—
  - Chemical research applied to industry . . . 245
  - Experiment *v.* observation . . . 61
  - Government Laboratory, London . . . 263
  - Manipulative skill . . . 95
  - Notes on chemical research . . . 27, 60, 93, 129, 177, 203, 245, 281, 353, 381
  - Patent literature . . . 94
  - Preliminary search for past records . . . 94
  - Protection by patent . . . 381
  - Publication of results . . . 353
  - Recording results of research . . . 352
  - Research, definition of . . . 60
  - Research, facility for in this country . . . 381
  - Research, historical review and nature of . . . 27
  - Research in relation to analysis . . . 315
  - Scientific investigation . . . 96
  - Scientific investigation, chemical and general . . . 177
  - "Scientific method in cellulose investigation" . . . 333
- "Resin and wood pulp industries, aspects of the" . . . 369
- "Respiratory enzymes" . . . 69, 107
- Reviews of books, etc. . . . 29, 67, 99, 138, 175, 210, 241, 279, 317, 357, 389, 428
  - "Alkali," etc. (reports) . . . 321
  - "Allen's Commercial Organic Analysis," Vol. V. . . . 31
  - "An Experimental Course of Physical Chemistry" (Spencer) . . . 100
  - "Annual Tables of Constants and Numerical Data, Chemical, Physical and Technological" . . . 389
  - "Applied Chemistry, Dictionary of" (Thorpe) . . . 317
  - "Assaying and Metallurgical Analysis" (Rhead and Sexton) . . . 139
  - "Bleaching and Dyeing of Vegetable Fibrous Materials" (Hübner) . . . 241
  - "Bread-making, The Technology of" (Jago) . . . 279
  - "Cast Iron" (Hatfield) . . . 175

- Reviews of books, etc.—(*continued*) PAGE
  - "Chemical Works: Their Design, Erection, and Equipment" (Dyson and Clarkson) 211, 242
  - "Chemistry of Bread-making" (Grant) 139
  - "Chemistry of Coal Tar Dyes" (Fay) 68
  - "Clays, Shales and Sands, An Introduction to British" (Searle) 429
  - "Cocoa and Chocolate" (Whymper) 29
  - "Commercial Organic Analysis" (Allen's) 31, 317
  - "Dictionary of Applied Chemistry" (Thorpe) 175
  - "Einführung in die Qualitative Chemische Analyse" (Wiechowski) 389
  - "Electro-analysis" (Smith) 100
  - "Elementary Text Book of Metallurgy" (Sexton) 176
  - "Geo-chemical Interpretation of Water Analysis" (Palmer) 139
  - "Higher Mathematics for Chemical Students" (Partington) 190
  - "Historical Papers on Modern Explosives" (MacDonald) 139
  - "Introduction to the Study of Fuel" (Brislee) 175
  - "Leçons de Cristallographie" (Friedel) 389
  - "Lectures on Cement" (Blount) 139
  - "Lubrication and Lubricants" (Archbutt and Deeley) 389
  - "Manufacture of Chemical Manures" (Fritsch) 67
  - "Manufacture of Sulphate of Ammonia" (Calvert) 99
  - "Metallurgy" (Borchers) 318
  - "Methods of Air Analysis" (Haldane) 211
  - "Microbiology" (Marshall) 99
  - "Micropetrology for Beginners" (Rhodes) 317
  - "Modern Explosives, Historical Papers on" (MacDonald) 318
  - "Nitro-cellulose Industry" (Worden) 99
  - "Notes on Foundry Practice" (Morgan) 357
  - "Paint Technology and Tests" (Gardner) 138
  - "Principles of Bleaching and Finishing of Cotton" (Trotman and Thorp) 31
  - "Prüfung der Chemischen Reagenzien auf Reinheit" (Merck) 139
  - "Public Health Chemistry and Bacteriology" (McKail) 389
  - "Qualitative Chemical Analysis of Inorganic Substances" (Tower) 176
  - "School Chemistry" (Wilson and Hedley) 176
  - "Simple Carbohydrates and the Glucosides" (Armstrong) 389
  - "Smoke" (Cohen and Ruston) 241
  - "Substitute for Horn and Celluloid" 178
  - "The Chemistry of the Rubber Industry" (Potts) 210
  - "Theoretical Chemistry" (Nernst) 30
  - "Volumetric Analysis" (Hampshire) 357
  - "Water Analysis" (Stocks) 279
  - "Wood Pulp and its Uses" (Cross, Bevan, and Sindall) 31
  - "Who's Who in Science" (Stephenson) 68
- Revis, C., and Bolton, E. R. ("Oils Fats, and Milk Products") 14, 83, 192, 408
- "Rhodesia, Food Products of" 309, 349
- Rhodesia, tobacco growing in 63
- Ribbon metal 57
- Rideal, E. K. ("The Electro-chemical Production of Ozone") 380
- Rideal, S. ("Alkaline Waters of the London Basin") 299
- Rideal, S. ("Origin of Carbonate of Soda in Natural Waters and Mineral Deposits") 15
- Rideal, S. ("Purification of Glasgow Sewage") 154
- Rideal, S. ("Recent Developments in the Chemical Purification of Drinking Water") 82
- Rideal, S. ("Water Purification") 225
- Rosenhain, W. ("Developments of Metallography") 149
- Royal College of Science 17
- Rubber and its cultivation 119, 153
- Rubber and rubber products 59
- Rubber export statistics (F. M. S.) 143
- Rubber plantations 261, 370, 409
- Rubber substitutes 323
- Rubber, synthetic 251
- Rubies 81
- Rubies and sapphires, artificial 359
- Rule, A. ("Chemical Department of University of Liverpool") 301
- Russell, E. J. ("Nitrogen Cycle in the Soil") 185
- Russell, E. J. ("The Chemical Characteristics of Soils") 5

S.

- Sand, H. J. S. ("Present Position of Electro-analysis") 53, 127
- Saponification, crude glycerine 431
- Sapphires and rubies, artificial 359
- *Sarco* combustion recorder 140
- Scholarships, Agricultural Research 348
- Scholarships, bequests for 322
- Scholarships for California 428
- Science and commerce 74
- "Scientific control of tobacco growing in Rhodesia" 63
- "Scientific method in cellulose investigation" 84
- Selenium 231
- Seligman, R. ("Aluminium") 232
- Sell, W. J. ("The Chemical Laboratory of the University of Cambridge") 85
- Sewage purification 154
- Sheet metal casting 57
- Shellac, use in food products 142
- Silk and artificial silk 218
- Silk imports and manufacture statistics 110
- Simmance-Abady combustion recorder 211
- Simmonds, C. ("The Government Laboratory, London") 263
- Slag and Portland cement 8
- "Smoke abatement" 115
- Soap from waste soda liquors 394
- Soap lyes crude glycerine 431
- Soap, the cleansing action of 46
- "Soaps, New Perfumes for" 214
- Societies, Institutions, and Meetings:—
  - Bio-Chemical Club 44, 89
  - British Association 306, 348
  - Chemical Industry and Engineering Exhibition 152
  - Chemical Society 44, 89, 126, 152, 204, 372, 410
  - Chemical Society Research Funds 209
- Societies, Institutions, and Meetings—(*continued*)
  - Congress of Mathematicians 312
  - Cornwall Joint Scientific Reception Committee 233
  - Eighth International Congress of Applied Chemistry 382
  - Faraday Society 12, 234
  - Institute of Chemistry 12, 44, 143, 244, 372
  - Institute of Chemistry Building Fund 325, 428
  - Institute of Chemistry Examinations 322
  - Institute of Chemistry Lectures 34, 70, 92, 410
  - Institute of Chemistry Pass List 207, 272
  - Institute of Metals 12, 44, 126, 321
  - Institute of Metals' Corrosion Research 122
  - Institution of Civil Engineers 410
  - Institution of Mechanical Engineers 410
  - International Association of Leather Trades Chemists 348
  - International Chemical Congress 382
  - International Congress of Applied Chemistry, Eighth 126
  - Iron and Steel Institute 269
  - Iron and Steel Institute, Autumn Meeting 392
  - Leather Trades Chemists, International Association of 308
  - Optical Convention, 1912 204, 254
  - Royal Institution of Great Britain 44, 89, 126, 204, 410
  - Royal Society of Arts 152, 254, 428
  - Royal Society of Edinburgh 428
  - Scientific and Technical Societies, Meeting in Cornwall 311
  - Society of Arts 410
  - Society of Chemical Industry 12, 44, 89, 126, 152, 204, 372
  - Society of Chemical Industry, Annual Meeting of 390
  - Society of Chemical Industry, New York Meeting 348
  - Society of Dyers and Colourists 152
  - Society of Public Analysts 126, 152, 204, 372, 410
- Soils, the chemical characteristics of 5
- Solids suspended in liquids 96
- "Soot: Its Character and Effects" 121
- "Specific Gravity Balls, Density determinations by" 280
- Starch, conversion to dextrin by X rays 250
- Starch factories 286
- Steam boilers on surface combustion principle 199
- Steam raising 103
- Steel rails, breakage of 392
- *Stereophagus* pump 205
- Stevens, H. P. ("Latex Formation") 261, 370, 409
- Stevens, H. P., and Beadle, C. ("Rubber and its Cultivation") 119, 153
- Stewart, A. W. ("Magnetic Susceptibility") 221
- Stewart, A. W. ("Sir William Ramsay") 123
- Stewart, A. W. ("The Determination of Chemical Constitution") 415
- Stiasny, E. ("Reactions of the Tanning Process") 285
- Strange, E. H. ("The Casting of Continuous Metal Sheets and Ribbons") 57
- Streatfeild, F. W. ("City and Guilds of London Technical College, Finsbury") 373

PAGE
"Substitution" 218
Sugar-beet 277
Sugar-beet industry, notes on the . 101, 131
Sugar cane crushing mill . . . 32
Sulphate of ammonia 8
Sulphate of ammonia enterprise in New Brunswick 105
"Sulphur, allotropy of" . . 231, 305
Sulphur mining in Japan . . . 179
Sulphur, nacreous. 161
Sulphur, prismatic 161
Sulphur production and trade in Sicily 430
Sulphur, rhombic 161
Sulphur, tabular 161
Sulphuric acid manufacture, the theory of 174
Surface combustion, and its practical developments 198
Swiss cheese, origin of holes in . . 395
Symptoms of lead poisoning. . . 113
Synthesis by enzyme action . . . 117
Synthesis of natural alkaloids . . 220
Synthetic rubber 251, 323

T.

Tanning 52
"Tanning process, reactions of the" 285
"Technical education, problems in" 307
Tellurium 231
Temperature regulation 166
"Terpenes, The" 331, 365
Testing building materials . . . 48
"The closed ring" 38
Thermo-regulator for industrial purposes 166
Thermo-regulators 33
Thompson, H. V., Meldola, R., and Hale, A. J. ("Isopicramic Acid") 327
Thorium 410
Thresh, J. C. ("The Alkaline Waters of the London Basin") . . . 393
Tiltometer chemical injector, the . 133

PAGE
"Tin, allotropy of" 377
Tin, grey and white 378
Tin-Pest 377
Tobacco and sugar, home-grown . 182
Tobacco, curing of 8
Tobacco-growing in Rhodesia . . 63
Townsend, E. R. ("Scientific Control of Tobacco Growing in Rhodesia") 63
Treasury grants to Universities . . 163
Tunny oil from Sicily 323
Turner, T. ("Volatility of Metals in a Vacuum") 257
Turpentine, ozonized oil of . . . 359
Tutton, A. E. H. ("Recent Advances in Chemical Crystallography") . 399

U.

Universities and Colleges :—
  Bradford Technical College, Chemical Department . . 195
  City and Guilds of London Technical College, Finsbury . 373
  Imperial Institute Scientific Laboratories 227
  Leathersellers' Company's Technical College, Bermondsey 49
  Liverpool 301
  Mussprat Physical Laboratory, equipment of 303
  Royal College of Science, Chemical Department 17
  University College, London . 124
  University of Birmingham, Chemical Department . . 157
  University of Bristol, Chemical Department 411
  University of Cambridge, Chemical Laboratory . . 85
  University of Cambridge, Department of Agriculture . 335
Uranium and its uses 431

PAGE
V.

"Vacua, New System for the Production of very high and pure" . 164
Vacuum evaporation, recent improvements in 423
"Vitalism" 326
Vulcanised rubber 119

W.

Washing medium, a new . . . 359
Water bath regulators 34
Water purification 225
Water softening and purification . 238
Wax, candelilla 287
Weevers, T. ("The Action of the Respiratory Enzymes of Sauromatum Venosum Schott") . 69, 107
White lead 294
Williams, H. ("Simple Method for the Production of Pure Ferrocyanides of the Heavy Metals") . 43
Wood alcohol trade in Japan, regulations for the 359
Wood pulp 249
Wood pulp and resin industries . . 369
Woods, composition of coniferous . 193
Wood, T. B. ("The Department of Agriculture of the University of Cambridge") 335

X.

X Rays 250

Z.

Zeitlin, J. ("New System for the Production of very high and pure Vacua") 164
Zinc-copper alloys 172
Zinc oxide 295

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